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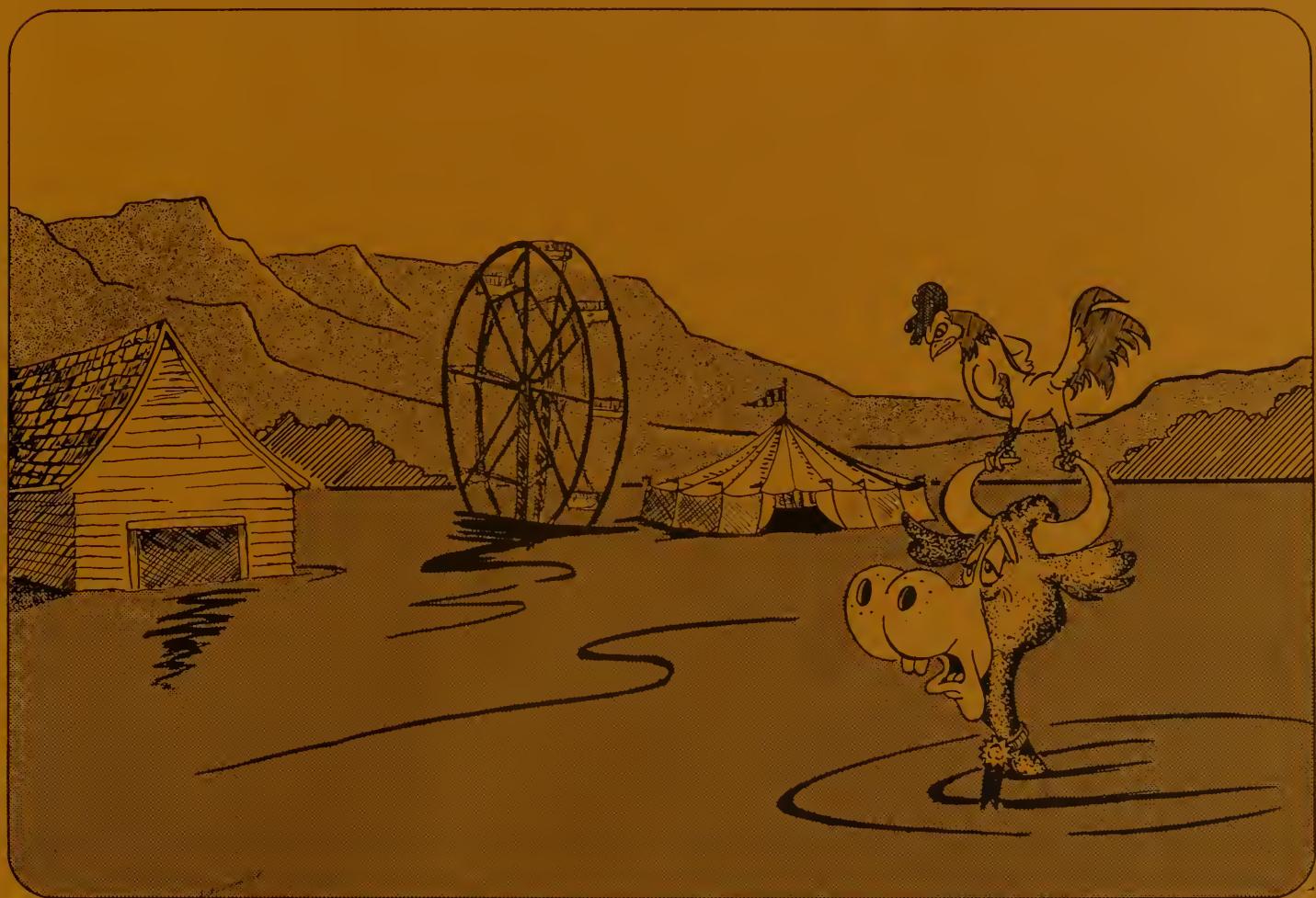


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## WATERSHED WORK PLAN

# ALKALI CREEK WATERSHED

Yellowstone County, Montana



Prepared under the authority of the Watershed Protection & Flood  
Prevention Act (Public law 566, 83rd Congress,  
66 Stat. 666) as amended.

JANUARY 1975

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ALKALI CREEK WATERSHED

Yellowstone County, Montana

Prepared Under the Authority of the Watershed  
Protection and Flood Prevention Act (Public  
Law 566, 83d Congress, 68 Stat. 666), as amended.

Prepared by: Yellowstone County  
Yellowstone Conservation District

With assistance by:

U. S. Department of Agriculture, Soil Conservation Service

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## T A B L E   O F   C O N T E N T S

## ALKALI CREEK WATERSHED

## Yellowstone County, Montana

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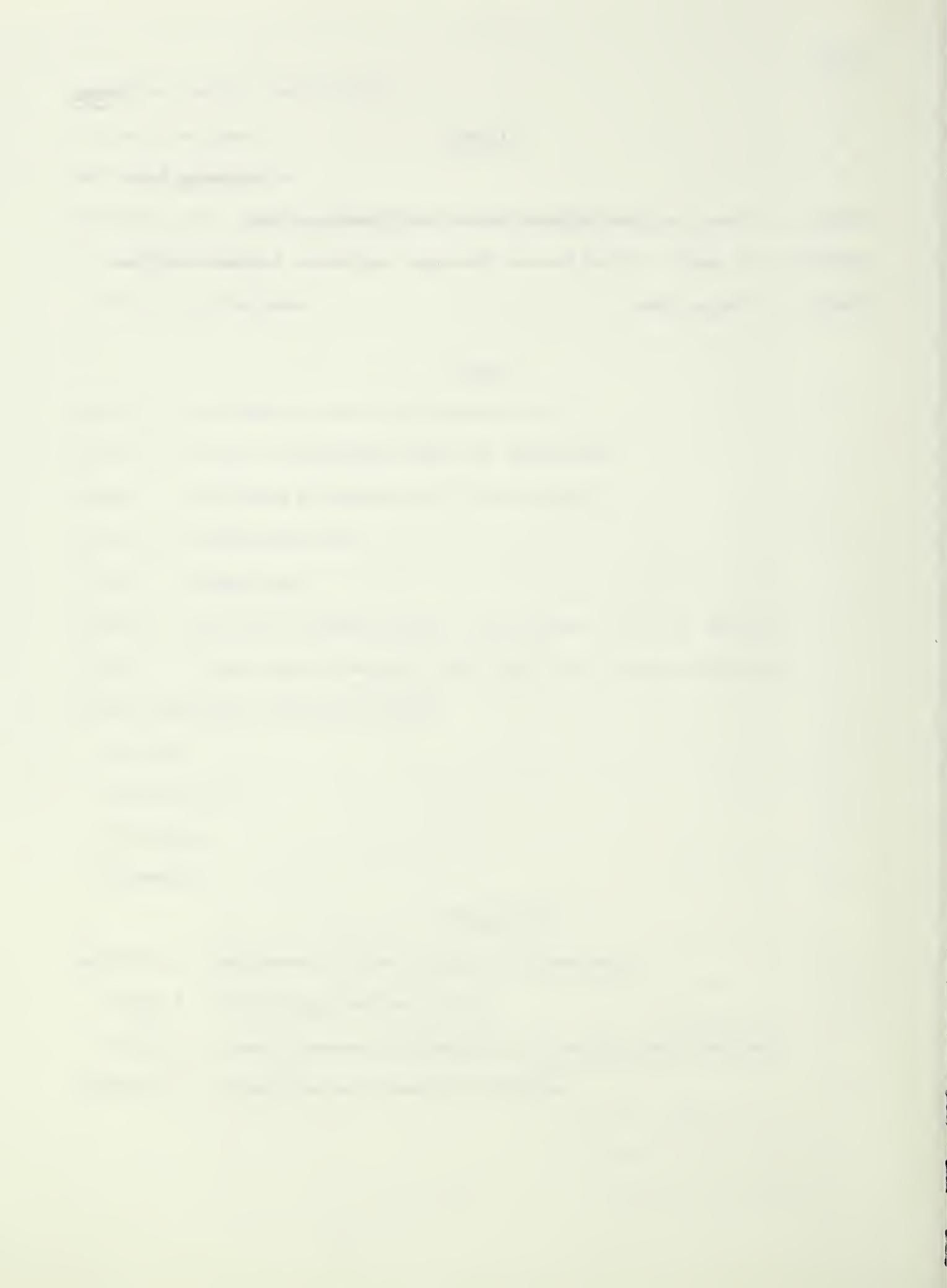
FIGURES

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FIGURE 1 - Cross Sections Bypass Channel and Diversion Dam

FIGURES 2, 3, and 4 - Flood Hazard Photomaps and Water Surface Profiles

FIGURE 5 - Project Map



WATERSHED WORK PLAN AGREEMENT

Between the

YELLOWSTONE COUNTY

YELLOWSTONE CONSERVATION DISTRICT

(hereinafter referred to as the Sponsoring Local Organization)

State of Montana

and the

Soil Conservation Service  
United States Department of Agriculture  
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Alkali Creek Watershed, State of Montana, under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Alkali Creek Watershed, State of Montana, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture through the Service hereby agree on the watershed work plan and further agree that the works of improvement as set forth in said plan can be installed in about four years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Sponsoring Local Organization will acquire with other than PL-566 funds such land rights as will be needed in connection with the works of improvement. (Estimated at \$321,000.)
2. The Sponsoring Local Organization assures that comparable replacement dwellings will be available for individuals and persons displaced from dwellings, and will provide relocation assistance advisory services and relocation assistance, make the relocation payments to displaced persons, and otherwise comply with the real property acquisition policies contained in the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646, 84 Stat. 1894), effective as of January 2, 1971, and the Regulations issued by the Secretary of Agriculture pursuant thereto. The costs of relocation payments will be shared by the Sponsoring Local Organization and the Service as follows:

	Sponsoring Local Organization <hr/> (percent)	Service <hr/> (percent)	Estimated Relocation Payment Costs* <hr/> (dollars)
Relocation Payments	52.9	47.1	0

\*Investigation has disclosed that under present conditions the project measures will not result in the displacement of any person, business, or farm operation. However, if relocations become necessary, relocation payments will be cost-shared in accordance with the percentages shown.

3. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to state law as may be needed in the installation and operation of the works of improvement.

4. The percentages of construction costs (\$243,800) of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows:

<u>Works of Improvement</u>	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
Bypass Channel & Diversion Dam	0	100	243,800

5. The percentages of the engineering costs (\$29,250) to be borne by the Sponsoring Local Organization and the Service are as follows:

<u>Works of Improvement</u>	Sponsoring Local Organization (percent)	Service (percent)	Estimated Engineering Cost (dollars)
Bypass Channel & Diversion Dam	0	100	29,250

6. The Sponsoring Local Organization and the Service will each bear the costs of Project Administration which it incurs, estimated to be \$4,880 and \$51,120, respectively.
7. The Sponsoring Local Organization will obtain agreements from owners of not less than 50 percent of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

8. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.
9. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.
10. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.
11. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.
12. This agreement is not a fund obligating document. Financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the availability of appropriations for this purpose.

A separate agreement will be entered into between the Service and the Sponsoring Local Organization before either party initiates work involving funds of the other party. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

13. The watershed work plan may be amended or revised, and this agreement may be modified or terminated only by mutual agreement of the parties hereto except for cause. The Service may terminate financial and other assistance in whole, or in part, at any time whenever it is determined that the Sponsoring Local Organization has failed to comply with the conditions of this agreement. The Service shall promptly notify the Sponsoring Local Organization in writing of the determination and the reasons for the termination, together with the effective date. Payments made to the Sponsoring Local Organization or recoveries by the Service under projects terminated for cause shall be in accord with the legal rights and liabilities of the parties.

14. No member of or delegate to congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.
15. The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964 and the regulations of the Secretary of Agriculture (7 C.F.R. 15.1-15.12), which provide that no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any activity receiving federal financial assistance.
16. This agreement will not become effective until the Service has issued a notification of approval and authorizes assistance.

Yellowstone County

By John E. Danner

Board of County Commissioners  
P. O. Box 1746, Billings, Mt. 59103

Address Zip Code

Title Chairman, Soil Conservation Commission  
Date March 14, 1975

The signing of this agreement was authorized by a resolution of the governing body of Yellowstone County

adopted at a meeting held on March 14, 1975

Merrill H. Klundt Billings, MT 59103  
Secretary, Board of County Commissioners County Clerk & Recorder Address  
Royce Orthwein, Sheriff Zip Code  
Yellowstone County Deputy

Date March 14, 1975

Yellowstone Conservation District

By Clinton L. Blakland

1629 Ave. D, Bldg. B, Suite 1  
Billings, Mt. 59102

Address Zip Code

Title Chairman, Yellowstone C.D.

Date Mar 14, 1975

The signing of this agreement was authorized by a resolution of the governing body of the Yellowstone Conservation District

adopted at a meeting held on March 14, 1975

John E. Danner  
Secretary  
Yellowstone Conservation District

1629 Ave D, Billings MT 59102  
Address Zip Code

Date March 14, 1975

Appropriate and careful consideration has been given in this work plan to the environmental aspects of this project.

Soil Conservation Service  
United States Department of Agriculture

Approved by:

Van E. Haederlie  
State Conservationist

3-14-75

Date

WATERSHED WORK PLAN  
ALKALI CREEK WATERSHED  
Yellowstone County, Montana  
January 1975

S U M M A R Y   O F   P L A N

The Alkali Creek Watershed is in southwestern Yellowstone County in southcentral Montana. The watershed originates about 10 miles northwest of Billings and outlets into the Yellowstone River at the Yellowstone County Fairgrounds. See Figure 5, Project Map. Alkali Creek Watershed contains 26,600 acres (41.6 square miles) and includes a portion of Billings.

This plan was developed and sponsored by Yellowstone County and Yellowstone Conservation District. Basic technical assistance was provided by the Soil Conservation Service, U. S. Department of Agriculture.

W A T E R S H E D   P R O B L E M S

The principal watershed problem is flooding. Flood damages along Alkali Creek occur primarily in Billings where the creek makes a large loop through the Yellowstone County Fairgrounds. Flood flows overtop the channel and spread out over a 165-acre area, including the fairgrounds and adjoining commercial area. Major floods on Alkali Creek have occurred in 1923, 1937, 1947, and 1958. Damage could be massive if a flood occurred just prior to or during one of the many scheduled events at the fairgrounds.

P R O J E C T   O B J E C T I V E S

The objectives of this project are to: reduce floodwater and sediment damages along the lower reaches of Alkali Creek, including protection of the Yellowstone County Fairgrounds; and to obtain information for management of the flood plain area along the lower reaches of Alkali Creek. The sponsors desire to coordinate flood control measures for the fairgrounds with the new Alkali Creek outlet channel planned by the City of Billings.

M E A S U R E S   T O   B E   I N S T A L L E D

Land treatment measures to be installed include proper grazing use, range deferred grazing, stockwater development, and conservation cropping systems (stripcropping and crop residue management). Land

treatment measures to be installed along lower reaches of the watershed and in urban areas include critical area plantings (seedings in urban areas), grassed waterways or outlets, heavy use area protection, and recreation area improvement.

Structural measures to be installed include a bypass channel through a narrow rimrock bluff and a diversion dam across Alkali Creek about 1,200 feet downstream from U. S. Highway 87.

Flood plain information and delineations for the 100-year flood plain along Alkali Creek between the project and the Five Fingers Lake site are provided for use by Yellowstone County and the City of Billings.

#### E N V I R O N M E N T A L      I M P A C T

The project will eliminate flood damages to areas of eastern Billings from flood flows originating in the Alkali Creek Watershed. The bypass channel and diversion dam will control runoff from 40.8 square miles or 98.2 percent of the contributing area above the Yellowstone County Fairgrounds.

Construction of the bypass channel and diversion dam will require the commitment of 7.0 acres of land. Another 5.1 acres may be used for borrow area. Use of this land at the present time is: 7.2 acres of Alkali Creek flood plain; 1.8 acres of road fill and railroad spur right-of-way; 0.7 acre of sandstone terrace; 0.3 acre of steep rimrock bluffs; and 2.1 acres of alluvial bottom lands of the Yellowstone River.

Flood plain management will prevent a buildup of damages and help preserve wildlife habitat in a 200-acre area along Alkali Creek.

Investigations indicate no archeological or historical features will be affected by the project.

#### P R O J E C T      I N S T A L L A T I O N

Structural and land treatment measures will be installed during a four-year period. Engineering services and the acquisition of land rights will begin the first year. Construction activities, including seeding, fencing, and restorative work will be concluded by the fourth year.

O P E R A T I O N , M A I N T E N A N C E  
A N D R E P L A C E M E N T

Yellowstone County will be responsible for carrying out operation, maintenance, and replacement of structural works of improvement. Average annual operation, maintenance, and replacement costs are estimated at \$2,310. This includes \$1,700 for replacement of rock riprap.

B E N E F I T S A N D C O S T S

The cost of applying land treatment measures on private land, estimated at \$37,730, will be borne by the individual landowners in conjunction with assistance as may be provided under going agricultural programs.

The total cost of project structural measures is estimated at \$650,050, of which \$324,170 will be borne by PL-566 funds and \$325,880 by other funds. Average annual benefits (\$75,670) divided by average annual costs (\$39,030) provide a benefit to cost ratio of 1.9 to 1.0.

W A T E R S H E D      R E S O U R C E S

A N D

E N V I R O N M E N T A L      S E T T I N G

H I S T O R I C A L      D A T A

The Alkali Creek Watershed is near Billings, Montana, in the heart of the Yellowstone River valley.

The Yellowstone valley was inhabited in the early 1800's by members of the Absarokee and Crow Tribes. One of the first expeditions by white men into the valley was the visit by Lewis and Clark in 1805-1806. A large sandstone pillar known as Pompeys Pillar, located about 30 miles downstream from Billings, contains the protected carving, "William Clark, July 25, 1806."

By 1875 a few traders had settled in the Yellowstone valley above Billings. In the same year, the steamer "Josephine" tied up at what is now the site of Josephine Park on the south side of Billings. This marked the farthest point reached on the river by steamer.

Hostility with the Sioux Indians climaxed in 1876 by the famous "Battle of the Little Big Horn." Settlement in the valley was deterred for several years following this conflict.

The new town of Billings was platted and the first permanent structure completed in May 1882. Billings was named after Frederick Billings, Sr., who was president of the Northern Pacific Railroad from 1879 to 1881. The first shipment of cattle left Billings by rail on September 11, 1882. Billings rose almost overnight to a town of 1,500-2,000, thus earning the title of "The Magic City."

Billings continued to grow and by 1887 there were a water plant, flour mill, and private telephone lines. Sugar beet industry developed early and in 1906 a refinery was opened. The Huntley Irrigation Project, located about 15 miles downstream from Billings, was completed in 1907. This project, along with seven other federal projects, helps bring stability to agriculture in the valley.

Billings today is a city with a land area of more than 11 square miles and has a population of 61,581 according to the 1970 census. Billings serves a multicounty area in southern Montana and northern Wyoming containing over 250,000 people.

## PHYSICAL DATA

The Alkali Creek Watershed is in southwestern Yellowstone County in southcentral Montana. The watershed originates about 10 miles northwest of Billings and outlets into the Yellowstone River at the Yellowstone County Fairgrounds. See Figure 5, Project Map. Alkali Creek Watershed contains 26,600 acres (41.6 square miles) and includes a portion of Billings. The watershed is about 15 miles long and 3.5 miles wide, narrowing in the lower reaches. Elevations range from 3,085 feet mean sea level (msl) at the Yellowstone River to 4,240 feet msl in the upper watershed. Alkali Creek Watershed is in Water Resource Region 10 (Missouri), Subregion 10 (Lower Yellowstone), Land Resource Area 58 (Northern Rolling High Plains), and OBE Economic Area 95.

Alkali Creek flows generally in a southeasterly direction and passes through the northeastern portion of Billings. The lower reach of Alkali Creek flows through the Yellowstone County Fairgrounds and city waste water treatment plant outletting into the Yellowstone River. Generally, the lower reaches of Alkali Creek are deeply incised. The channel section through the fairgrounds is constricted and subject to overflow.

The watershed is in rolling plains country where sandstone rimrock outcrops are typical. Most of the watershed is covered by open range-land with some dry cropland. New residential subdivisions are being developed along lower reaches of Alkali Creek. At present there are ten residences within the 100-year flood level.

Alkali Creek Watershed is underlain by a thick sequence of sedimentary rocks, chiefly interbedded sandstone and shale. Bedrock formations in the watershed are the Eagle Sandstone Formation and the Claggett Shale Formation. The Eagle Formation outcrops over the lower two-thirds of the watershed and consists of massive and thin-bedded sandstones with some sandy shale lenses. The Claggett Formation lies above the Eagle Formation and consists of alternating beds of thin-bedded sandstones and soft sandy shales. The Claggett outcrops in the upper watershed. These formations dip gently to the northeast. Alluvial deposits cover bedrock along the valleys of the larger drainageways.

Topography of the watershed is the result of differential erosion between resistant massive sandstone and soft thin-bedded sandstone and shale. Gentle uplands comprise most of the watershed area. They are extensively dissected by steep-walled coulees where streams have cut through the resistant massive sandstone to softer thin-bedded sandstones and shales. Massive sandstone beds outcrop in prominent, steep cliffs (rimrocks) which, generally, separate the flat, narrow stream valleys from gently rolling, flat-topped uplands. The sandstone rimrocks that

face southwest are often higher and bolder than those that face northeast due to the dip of the rock strata. An example of these prominent rimrocks occurs north and east of Billings.

About 80 percent of the soils in the watershed are on uplands and 20 percent are in alluvial valleys. The upland soils are formed in place from the underlying shales and sandstones. The residual soils are mainly of the Wormser, Lavina, Cushman, Ryegate, Travessilla, Midway, and Renohill series. Ryegate and Travessilla soils have fine sandy loam texture; Cushman soils have loam texture; and the others have clay loam and silty clay loam texture. Soil depths range from less than 10 inches to 40 inches. Shallow soils are associated with steep slopes and rock outcrops. Soils of the alluvial valleys are mainly of the McRae, Glendive, and Heldt Series. They range in texture from fine sandy loam to silty clay loam and in depth from 5 to 15 feet.

The vegetative rangeland types in the watershed are the Central Grassland type and the Eastern Montana Ponderosa Pine Forest type. Principal forage species in the Central Grassland type include blue-bunch wheatgrass, western wheatgrass, and needle-and-thread. Other common species include plains prickly pear, silver sagebrush, blue grama, and phlox. Principal forage species in the Eastern Montana Ponderosa Pine Forest type are bluebunch wheatgrass, western wheatgrass, and bluegrass. Other species include western ponderosa pine, Rocky Mountain juniper, Idaho fescue, blue grama, needle-and-thread, and phlox. Present range condition is good to excellent.

Critical erosion areas in the watershed are confined to small construction sites in the urban area. Proper land use on the cultivated land and good livestock management on the rangeland result in a low rate of sediment production.

Land use divisions in the watershed are:

Rangeland, 78.3 percent	- 20,810 acres
Cropland, 11.2 percent	- 2,990 acres
Urban area, 10.5 percent (including airport, streets, fairgrounds)	- <u>2,800 acres</u>
TOTAL	- 26,600 acres

The Montana Department of Health and Environmental Sciences has classified Alkali Creek as a B-D<sub>3</sub> stream.<sup>1/</sup> Most of Alkali Creek is classified "I" (intermittent) and "N" (well-defined, unmodified channel). The lower two miles of stream channel are classified "Pr" (perennial) and "M" (previously modified channel, 1900 to present). In the past, the lower reach of Alkali Creek has been reported to have intermittent flow. In more recent years, small springs and a leaky irrigation siphon have given rise to a base flow of about one cfs. Drainage from a city storm sewer also discharges into Alkali Creek at the fairgrounds. The flow in Alkali Creek varies with seasonal and channel conditions and diminishes at the outlet on the Yellowstone River.

Moderate supplies of ground water are available in alluvial flood plain deposits of the watershed. Small shallow supplies can be obtained from the Eagle Sandstone in eastern portions of the watershed. Large supplies (100-500 gallons per minute) of artesian water could be obtained at depths exceeding 2,000 feet.

Deposits of commercial quality sands and gravels can be obtained from the lower portion of the watershed. Important petroleum resources have been developed north and east of the Alkali Creek Watershed. Exploration wells have been drilled, although no discoveries have been made in this watershed.

The climate of the watershed is semiarid. It is characterized by abundant sunshine and low relative humidity. The average annual precipitation at the Billings airport, on the southeastern edge of the watershed, is 13.23 inches for the period 1931 to 1960. Average annual precipitation over the entire watershed is from 13 to 15 inches. About 66 percent of this occurs during the growing season. About 33.5 percent of the average annual precipitation occurs in May and June. Average annual relative humidity is about 60 percent. Average watershed runoff is about 11 acre-feet per square mile per year. Evaporation from lakes and reservoirs averages 38 inches annually. Winters in this area are relatively mild compared with the rest of Montana. Annual snowfall averages about 54 inches.

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<sup>1/</sup> State Classification B-D<sub>3</sub> indicates water that shall be maintained suitable for drinking, culinary, and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary to remove naturally present impurities; bathing, swimming, and recreation; growth and propagation of nonsalmonid fishes and associated aquatic life, waterfowl, and furbearers; agricultural and industrial water supply. Specific water quality criteria can be obtained from: Montana Water Quality Standards Department of Health and Environmental Sciences RULE MAC 16-2.14(10)-S14480 Revised November 5, 1973.

Temperatures at the Billings airport vary from a record low of -38°F to a record high of +106°F with a mean annual temperature of 47.5°F. For the hottest month, July, the average daily maximum is 87.4°F and the average daily minimum is 58.6°F. During the coldest month, January, average daily maximum is 32.7°F and the average daily minimum is 13.3°F. The average frost-free period is 150 days between the last killing frost on about May 8 and the first killing frost on about October 5. Mean annual temperature range over the watershed is from 45°F to 48°F.

#### E C O N O M I C      D A T A

Billings is the important trade center for southern Montana and northern Wyoming. Agriculture and related industries are an important part of the overall economy. Billings is also an important center for product distribution, retail sales, wholesale distribution, medical facilities, education, transportation, manufacturing, and entertainment. The watershed, which includes a portion of Billings, has a population of about 2,000.

Approximately 4,950 acres of land are owned by the State of Montana. About 900 acres are owned by the City of Billings, including airport land. There are about 155 acres owned by Yellowstone County. The remaining 20,595 acres are privately owned.

Livestock ranches with dry cropland farming operations are typical throughout the upper watershed. There are nine farm and ranch headquarters in the watershed. The Billings Bench Water Association siphon crosses Alkali Creek about 0.75 mile upstream from U. S. Highway 87. The irrigated area served by this canal is outside the watershed.

Principal crops grown in the watershed are small grain, alfalfa hay, and pasture. Crop yields for wheat and barley average 31 bushels per acre. Carrying capacity on rangeland averages 0.25 animal unit month per acre.

Sales of land for farm and ranch use indicate a value for rangeland of about \$125 to \$150 per acre and \$200 per acre for cropland. Commercial land near the fairgrounds is being offered at \$70,000 per acre. Yellowstone County recently purchased a tract of land along Alkali Creek for about \$5,000 per acre. Commercial property typically ranges upward from \$60,000 per acre.

Urban growth trends indicate that residential growth will continue along lower reaches of Alkali Creek. Platted lots and subdivisions have been developed along the Alkali Creek and valley foothills. Only a few houses are in or near the 100-year flood plain along Alkali Creek.

Census data<sup>2/</sup> for Yellowstone County indicate that in 1970 there were 34,996 persons in the labor force, with 94.2 percent employed (32,966) and 5.8 percent unemployed (2,030). Employment in the labor force was distributed as follows:

<u>Occupational Group</u>	<u>Number</u>
Professional, technical, and kindred workers	4,727
Managers and administrators, except farm	4,020
Sales workers	3,108
Clerical and kindred workers	5,882
Craftsmen, foremen, and kindred workers	4,170
Operatives, except transport	2,123
Transport equipment operatives	1,575
Laborers, except farm	1,439
Farmers and farm managers	787
Farm laborers	386
Service, except private households	4,349
Private household workers	400
TOTAL	32,966

Census data for 1970 show that the annual median income in Yellowstone County was \$8,966. Annual mean income was \$10,103 and per capita income was \$2,439. Census data also indicate that there were 9.4 percent of the families below the poverty income level with a mean annual income of \$1,988 and mean income deficit of \$1,357. Median family income for Montana was \$8,512.

#### F I S H      A N D      W I L D L I F E      R E S O U R C E      D A T A

The Alkali Creek Watershed supports populations of a variety of wildlife species. Modest populations of mule deer, pronghorn antelope, sage grouse, and sharp-tailed grouse occur in the upper watershed. Habitat for mourning doves, song birds, and raptorial species is found along the creek bottom and adjacent bluffs and coulees. Mink, raccoon, and fox comprise the important fur species. Coyote, badger, skunks, and jackrabbits complement other wildlife in the watershed. Sport hunting in the watershed is limited by habitat deficiencies, urban pressure, and posting of private land. Hunting opportunities are very limited in the lower watershed due to urbanization.

Streams in the watershed above the Billings Bench Water Association siphon are intermittent and do not support a fishery resource. The lower two miles of Alkali Creek are considered perennial. This section is mostly modified channel without brush cover and has essentially no pools or riffles. This section does not support any fishery resource due to channel characteristics, low flows, and poor water quality.

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2/ U. S. Department of Commerce, Bureau of the Census. "General Social and Economic Characteristics," Montana. October 1971. (PC(1)-C28 Mont.)

## R E C R E A T I O N A L      R E S O U R C E S

Outdoor recreational facilities in the watershed are primarily those provided in connection with the Yellowstone County Fairgrounds. Other recreational resources are limited to commercial establishments such as riding stables, rifle ranges, guest ranches, and drive-in theaters. Hiking, picnicking, and camping activities in the rural portions of the watershed are restricted because of private ownership. The Black Otter Trail is located in the rimrocks of the lower watershed. This short scenic drive provides overlooks of Billings and the Yellowstone County Fairgrounds. The Boot Hill Cemetery is located along this route. Tombstones of many pioneers are located there. Of special interest is the grave of Yellowstone Kelly.

## A R C H E O L O G I C A L      A N D H I S T O R I C A L      V A L U E S

An archeological survey was made of the watershed area below Highway 87 by the University of Montana Statewide Archeological Survey. The investigation revealed a flake of moss agate. A small rock shelter was noted outside the proposed construction area. The upper watershed has several sites where Indian pictographs can be seen under sandstone overhangs. The watershed does not contain any places listed on the National Register of Historic Places. In consultation with the Montana State Historic Preservation Officer, it has been determined that there are no places in the proposed construction area that are eligible for inclusion in the National Register of Historic Places.

## S O I L ,      W A T E R ,      A N D P L A N T      M A N A G E M E N T      S T A T U S

Land use in the upper watershed consists of dry cropland and rangeland. These uses are expected to continue in the future.

Land use in the lower watershed is slowly changing from rangeland to urban as the population of Billings increases. Subdivision is occurring and new houses are being built.

Alkali Creek Watershed is entirely within Yellowstone Conservation District. Landowners and operators receive assistance from the District in applying needed land treatment measures.

Ten cooperators in the watershed have 6,560 acres of private lands under agreement with the Yellowstone Conservation District. Eight cooperators have basic conservation plans.

About 27 percent of the needed land treatment practices, based on a dollar value, have been applied in the upper watershed. See Table 1A. This represents more than 90 percent of the presently planned practices. Land treatment measures applied on dry cropland include conservation cropping systems and crop residue management. Measures applied on rangeland are proper grazing use, range deferred grazing, stockwater ponds, spring and well developments, and stock-water pipelines.

W A T E R    A N D    R E L A T E D    L A N D  
R E S O U R C E    P R O B L E M S

L A N D    T R E A T M E N T

Land treatment problems in the upper watershed are minor. Proper land use in the past has contributed to a low average annual rate of sediment production for the watershed. Urban development in the lower watershed will increase future land treatment needs.

Rangeland, covering 78.3 percent of the watershed, is in good to excellent condition. Major land treatment needs are continued proper grazing use and stockwater development to improve livestock distribution. Cropland, covering 11.2 percent of the watershed, is used for grain, hay, and pasture production. Continuation of existing conservation cropping systems on 96 percent of the cropland and improving systems on four percent will provide the primary land treatment needs.

Subdivisions and the urban area along the lower reaches of Alkali Creek currently cover 10.5 percent of the watershed. Much of this area is presently undeveloped. As urban development progresses, conservation measures will be needed to hold runoff, erosion, and sediment production to a minimum. Protection of the surrounding area will be needed as recreational use increases.

F L O O D W A T E R    D A M A G E

Major floods on Alkali Creek have been caused by intense rainfall during spring and summer thunderstorms. Snowmelt, accelerated by chinook winds, has also produced flooding. Floodwater damages occur primarily to the Yellowstone County Fairgrounds and adjacent urban area.

Flood damages along Alkali Creek occur primarily in Billings where Alkali Creek makes a large loop through the Yellowstone County Fairgrounds. Flood flows overtop the channel and spread out over a 165-acre area. Existing highways, railroads, and levees along the Yellowstone River contribute to increased depths and prolong periods of inundation. Property value in the hazard area is estimated at over \$9,700,000, exclusive of the waste water treatment plant, streets, and utilities. This area contains the Yellowstone County Fairgrounds, about 20 businesses, several residences, and a U. S. Army Reserve depot. Business establishments include pipeline company control stations, truck service and sales centers, automotive parts supply houses, livestock auction yards, and other wholesale and retail establishments. Buildings at the fairgrounds include a grandstand, race track, exhibition buildings, livestock barns, administration building, and caretaker residence. County shops are being relocated from a portion of the fairgrounds area.

Major floods on Alkali Creek have occurred in 1923, 1937, 1947, and 1958. The largest flood of record was on June 12, 1937, with a discharge of 13,000 cubic feet per second estimated by the U. S. Army Corps of Engineers. The second largest flood occurred July 25, 1923. This flood was caused by a cloudburst in the upper portion of the watershed. The duration of flood flows is short, lasting only a few hours. Minor floods have occurred about every five years. Past floods have carried large amounts of sediment, debris, filth, and pollution into the damage area from the upper watershed.

Damages to the Yellowstone County Fairgrounds in the 1937 flood were reported to be in excess of \$200,000. See Photo Plates 1-6. It is estimated that this storm would cause more than \$1,750,000 of damages based on 1974 prices. This storm would have a frequency of occurrence of approximately once in 500 years.

Agricultural damages in contrast to urban damages are usually insignificant. Very little agricultural use is made of the lower reaches of Alkali Creek where major flood flows occur. A large irrigation siphon, belonging to Billings Bench Water Association, was washed out in the 1937 flood causing an interruption of water delivery to about 18,000 acres for six weeks and \$216,000 of damages to crops. This siphon was rebuilt with additional clearance to pass flood flows. Agricultural damages are usually limited to fence washouts, minor livestock losses, and debris deposition.

Damages to the fairgrounds and adjacent commercial area from a 100-year storm are estimated at \$673,900. (A 100-year storm is expected to occur on the average once in 100 years, or has a one percent chance of occurrence in any given year.) Damages could be massive if a flood occurred at fair time and the grounds were heavily occupied with people and equipment.

Indirect damages also occur at the fairgrounds including: interruption of scheduled activities including entertainment contracts; damage to buried utility lines; traffic delays and detours; and interruption of farmers' and ranchers' schedules for livestock shows.

Average annual floodwater and sediment damages are estimated at \$46,930 for the fairgrounds and adjacent commercial area. See Table 5. This includes \$32,770 for damages to the fairgrounds; \$4,750 for damages to businesses; \$230 for damages to streets and storm sewers; and \$9,180 for indirect damages. Indirect damage includes such things as traffic detours, disruption of community activities and inoculations. Average annual damages to agriculture are small and were not evaluated.

Average annual damage estimates include projected increases in the standard of living which will result in higher value inventories and equipment.

## EROSION AND SEDIMENT DAMAGE

There are no major sources of sheet or gully erosion in the watershed. Minor streambank and channel erosion is occurring along some reaches of Alkali Creek. Sediment yield in the watershed, from all sources, is estimated at 0.14 acre-foot per square mile per year. Sediment and erosion damages are included in the floodwater damage estimates.

## MUNICIPAL AND INDUSTRIAL WATER

The Billings municipal water distribution system is inadequate to meet present demands. Shortages are most critical during the summer months due to inadequate pumping plant and pipeline capacity. Billings now obtains most of its water from the Yellowstone River. This source is considered adequate to meet present and future needs. Feasibility studies of alternate methods for supplying municipal water are under way. See "Projects of Other Agencies."

## RECREATION

Billings now has limited water-based recreational facilities. This shortage is expected to become worse as the population of Billings and surrounding area grows. Yellowstone County is projected to grow from 87,367 (1970 census) to 210,000 by 2020. This projection was made by U. S. Bureau of Reclamation for the current Billings Water Supply Study.

## FISH AND WILDLIFE

There is a continuing loss of grass and tree plant communities along the lower reaches of Alkali Creek due to urban development. Portions of existing habitat need protection. Damages occur to the fishery habitat in the Yellowstone River from pollution which is washed in by Alkali Creek flood flows.

There are no endangered species in the watershed.

## ECONOMIC AND SOCIAL

The Yellowstone County Fairgrounds are used heavily throughout the year. The fairgrounds are an important social center for the community and surrounding multicounty area. The Alkali Creek channel through the fairgrounds restricts development and increases maintenance and construction costs for new building development.

NOTE: Pictures used in Photo Plates 1-6 furnished by Yellowstone County Commissioners and Midland Empire Fair Board (Yellowstone Exhibition).

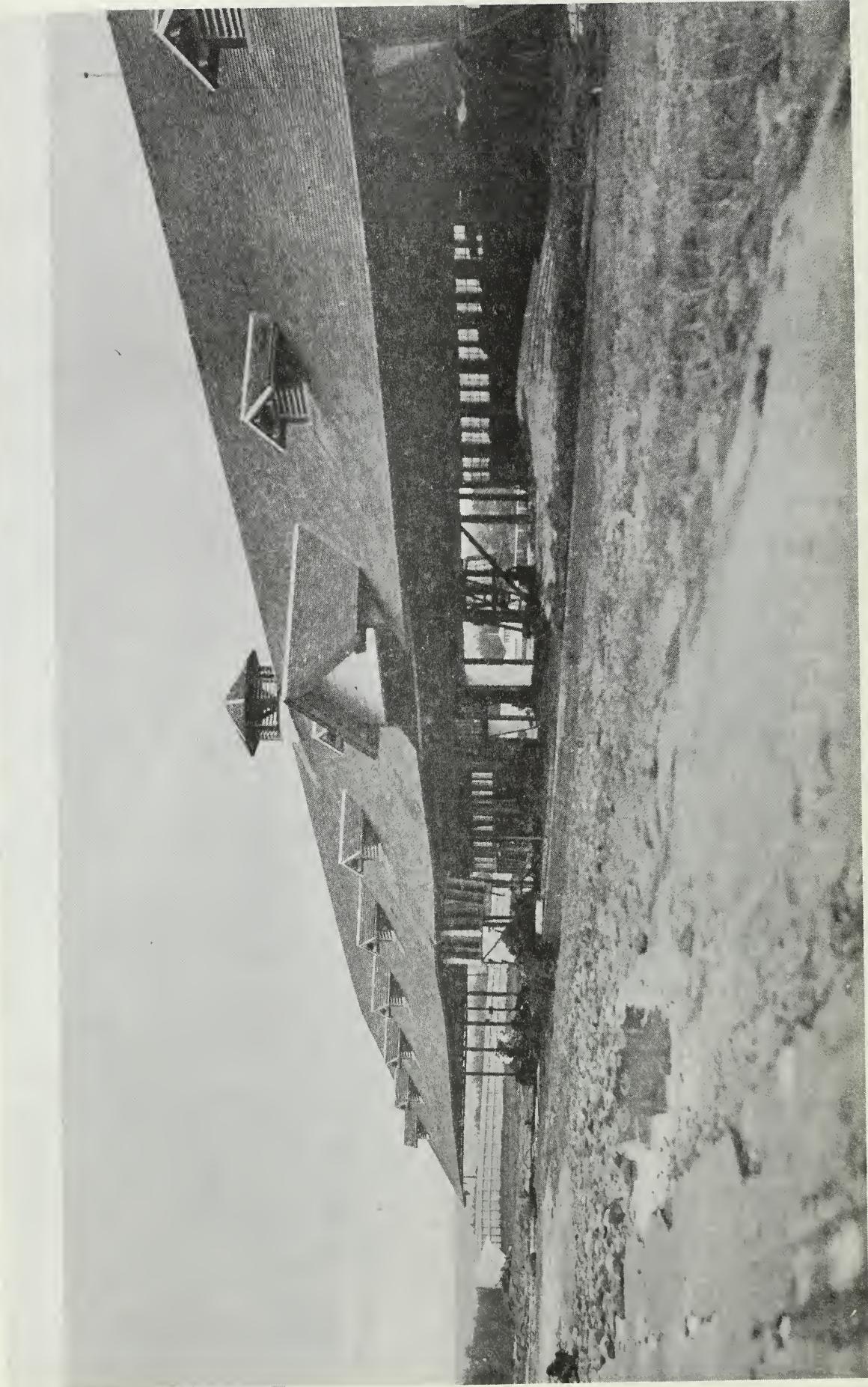
PLATE 1



Western Photo Shop Photo

View of Midland Empire Fair (August 12, 1936). In addition to extensive building damage during the June 11, 1937, flood, the artificial lake shown above was also destroyed.

PLATE 2



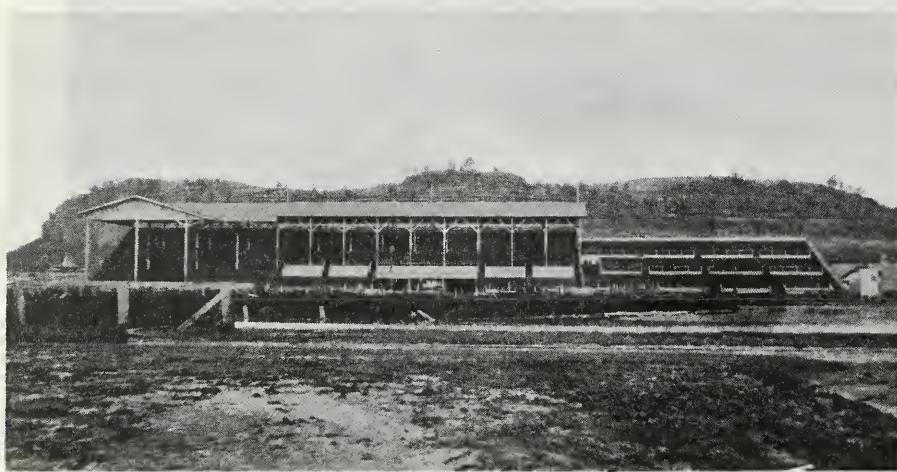
The sides of the poultry house were washed out in the June 11, 1937, flood.

PLATE 3



The westerly 100 feet of the sheep barn was washed away during the June 1937 Flood.

PLATE 4



*Note damages at  
grandstand up to  
window level.*



*Damages to the grandstand were severe in the 1937 flood. One third of the structure was destroyed. The grandstand was rebuilt in 1948.*

PLATE 5



*Debris was widely scattered over the fairgrounds in 1937 flood.*

PLATE 6



*Damages at the fairgrounds resulting from the June 1937 flood which destroyed fences, buildings, roads, and other facilities. Cleanup was costly.*

## PROJECTS OF OTHER AGENCIES

The U. S. Army Corps of Engineers has made several studies of flood problems in Billings and adjoining areas, including the lower reaches of Alkali Creek. A 1941 report described the damages caused by the 1937 flood. The Corps of Engineers has an authorized project on lower Alkali Creek which consists of a cutoff channel to reroute Alkali Creek to the Yellowstone River. The project was authorized by the Flood Control Act of 1950. A general design memorandum was completed in 1957; however, the project is currently in an "inactive" classification. In 1969 a report was prepared for Billings containing flood plain information for a 15-mile reach of the Yellowstone River around Billings. The report also contained information for about 2.5 miles of the lower Alkali Creek flood plain above the fairgrounds.

The U. S. Bureau of Reclamation is currently studying alternative proposals for expansion of the Billings municipal water supply. Current studies are being directed to the more feasible proposed reservoir sites west of Billings. The Five Fingers reservoir site was also considered.

The City of Billings waste water treatment plant is being expanded under a multimillion-dollar project funded primarily by the Environmental Protection Agency. Flood protection is required for these facilities. An outlet channel, under construction, will divert Alkali Creek around the south boundary of the plant to the Yellowstone River.

## PROJECT FORMULATION

### INTRODUCTION

An application for assistance under Public Law 566 was submitted by the sponsors and approved by the State Soil Conservation Committee for the Governor on June 16, 1966.

Numerous special meetings have been held with the sponsors and the Billings Public Utilities Department during preliminary and advance planning stages to discuss various alternatives and incorporate their ideas. Input was requested and received from other concerned agencies and groups, including U. S. Army Corps of Engineers; U. S. Bureau of Reclamation; U. S. Fish and Wildlife Service; Montana Department of Fish and Game; City of Billings; Executive Advisory Board, Multi-Use Building; Five Fingers Lake Committee; Christian, Spring, Sielbach and Associates; Black and Veatch of Kansas City, Missouri; Burlington Northern Inc.; Montana Power Company; Montana-Dakota Utilities; Mountain Bell Telephone Company; and Continental Pipeline Company. Other interested agencies and groups were furnished copies of the preliminary investigation report and asked to comment.

Two public meetings were held--one for presentation of the preliminary investigation report on September 12, 1973, and one for presentation of the draft work plan. Communications were maintained with sponsors and affected agencies and groups during the planning process.

The Alkali Creek Watershed project (14-28B) is identified as one of the water control features in the 1980 Framework Plan shown in the June 1969 Type I Comprehensive Framework Study for the Missouri River Basin.

### PROJECT OBJECTIVES

The basic objective of the sponsors in their application for assistance is to reduce floodwater and sediment damages along the lower reaches of Alkali Creek, including protection of the Yellowstone County Fairgrounds. Protection from storms exceeding the largest storm expected once in 100 years is considered needed for this purpose. The largest flood of record on Alkali Creek occurred in 1937. The U. S. Army Corps of Engineers estimated the discharge at 13,000 cubic feet per second (cfs). A flood in 1923 was reported to be similar in magnitude to the 1937 flood. The Standard Project Flood, as used by the U. S. Army Corps of Engineers, is 15,000 cfs on Alkali Creek. A 15,000 cfs discharge was selected for planning protection of the fairgrounds based on the 1937 flood, hydrologic analyses, and the proposals of the U. S. Army Corps of Engineers.

Development of water-based recreation is another objective of the sponsors in their application for assistance. Billings and the surrounding urban area have an estimated population of 80,000 persons. The Billings area has limited water-based recreational facilities.

A third objective of the sponsors is to obtain information for management of the flood plain area along the lower reaches of Alkali Creek. Flood plain management is desired to protect existing wildlife habitat and minimize future development within the 100-year flood plain.

The sponsors want to coordinate flood control measures for the fairgrounds with the new Alkali Creek outlet channel planned by the City of Billings. This outlet channel to the Yellowstone River is part of the overall flood protection plan for the expanded Waste Water Treatment Plant. Land transfer agreements and right-of-way easements were made between Yellowstone County and City of Billings in 1973. The City of Billings plans to begin construction of the new channel by spring of 1974.

#### ENVIRONMENTAL CONSIDERATIONS

Consideration was given in formulating the proposed action to environmental factors which are important in the watershed such as: (1) seasonal flows and yield of Alkali Creek; (2) existing streambank riparian vegetation; (3) existing pollution of the lower reaches of Alkali Creek; (4) fish and wildlife resources of the watershed; (5) appearance and esthetic values along Alkali Creek in the vicinity of the fairgrounds; (6) present land treatment program in the upper watershed, with emphasis on land use trends, cropland needs, range condition, and sediment sources; (7) archeological, historic, and cultural values in the watershed; (8) scenic values of natural features; and (9) impact of disruption to persons in the form of home or utility relocations.

Features were incorporated into the planned project to minimize adverse environmental impacts and to improve environmental conditions. The adopted plan incorporates land treatment, flood plain management, and a bypass channel. Environmental effects were also considered in evaluating each alternative action.

#### ALTERNATIVE PROJECT MEASURES

##### Land Treatment Only

Accelerated land treatment measures alone would maintain and improve the condition of the watershed, but would have little effect

on the present rate of runoff or flood damage reduction. Proper land use on the cultivated land and good livestock management on the range-land currently provide excellent hydrologic conditions with low runoff potential. Accelerated treatment will not reduce flood stages a measurable amount for flood protection along Alkali Creek. This alternative would not meet the objectives of the project.

#### Improvement of Existing Channel

Improvement of existing Alkali Creek channel through the fairgrounds would provide needed flood protection to the Yellowstone County Fairgrounds and adjacent commercial area. Alkali Creek is constricted along its upper portion through the fairgrounds by sandstone rimrocks and fairground development. The upper 2,200 feet of channel improvement would require a concrete-lined rectangular channel to carry a 15,000 cfs discharge, provide necessary grade control, and fit within minimum right-of-way. The lower 500 feet of earth channel improvement would connect with the new City of Billings outlet channel for Alkali Creek to Yellowstone River. About 300 feet of the concrete channel would need to be covered to provide access to the Multipurpose Community Center now under construction. Four road crossings would also be required.

The improved channel would practically eliminate all floodwater and sediment damages now occurring to the fairgrounds from Alkali Creek. Areas of ponded, stagnant water would be eliminated. Trash accumulation would be reduced. Less debris, manure, and pollutants from the fairgrounds would be flushed into Yellowstone River during flooding.

About 2,700 feet of existing modified stream channel would be altered. The concrete channel, even with protective fences, could be an attractive nuisance and hazardous. A temporary increase in dust and noise pollution would occur during project construction. Some utility relocation would be required.

The estimated installation cost of improving existing Alkali Creek channel, including crossings and land rights, is \$3,000,000.

Improvement of existing Alkali Creek channel would have high construction costs, undesirable location aspects, and associated costs of future use and development of the fairgrounds.

#### Multipurpose Floodwater Retarding and Recreational Reservoir

A multipurpose reservoir providing floodwater retarding storage and a recreational lake was proposed on Alkali Creek. This site, identified as Five Fingers Lake, is about seven miles upstream from

the outlet of Alkali Creek. A dam at this site would control 73.6 percent of the drainage area. The uncontrolled drainage area below the dam would be about 11 square miles. Therefore, the dam alone would not provide adequate floodwater protection to the Yellowstone County Fairgrounds. A diversion dam above the fairgrounds with bypass channel would also be needed to provide adequate floodwater protection.

Five Fingers Lake reservoir would provide flood protection for developed areas upstream from the fairgrounds and a 220-acre recreational lake. Salinity of soils in the watershed may cause poor quality water for recreational use. Low average annual water yield would require pumping of supplemental water from another source to fill and maintain the recreational pool. The reservoir would provide additional habitat for fish and wildlife in the watershed. The reservoir would reduce downstream sediment deposition and pollution.

The dam and reservoir would require about 500 acres to be committed to project use. Although a reservoir would improve visual quality of the area, increased use of the reservoir could result in damage to fragile adjacent land areas and create dust and nuisance problems to residents living nearby. A temporary increase in dust and noise pollution would occur during project construction.

Land rights in the reservoir basin would require relocation of two major power transmission lines, two oil pipelines, a county road, and two ranch headquarters. The estimated installation cost of the multi-purpose reservoir and bypass channel, including land rights, is \$3,200,000.

#### Single Purpose Floodwater Retarding Reservoir

A single purpose floodwater retarding reservoir was considered at the Five Fingers Lake site. This structure would require a diversion dam above the fairgrounds with a bypass channel to provide adequate floodwater protection to the Yellowstone County Fairgrounds.

A single purpose reservoir at Five Fingers Lake site would provide flood protection for developed areas upstream from the fairgrounds. The sediment pool would provide additional wildlife habitat in the watershed; however, salinity of soils in the watershed may create a saline pool. The reservoir would reduce downstream sediment deposition and pollution.

Land rights in the reservoir basin would require relocation of two major power transmission lines, two oil pipelines, a county road, and two ranch headquarters. Construction cost of the emergency spillway is higher for a single purpose reservoir. The estimated installation cost of a single purpose reservoir and bypass channel, including land rights, is \$3,200,000.

The proposed reservoirs at the Five Fingers Lake site would have high initial construction and land rights costs. The floodwater retarding portion of the reservoirs alone would not provide adequate floodwater protection to the Yellowstone County Fairgrounds. Development of a recreational lake in a multipurpose reservoir would have physical limitations. Pool size would not justify costs involved. There are no other feasible reservoir sites in the Alkali Creek Watershed for developing water-based recreation.

Sponsors should consider protecting the Five Fingers Lake area to discourage expansion or new development of permanent facilities. Reservation of this site for reservoir use could be considered for future municipal water and recreation development, although salinity conditions in the reservoir basin need to be further evaluated. Agreements with utility companies could be made for moving existing lines when enlargement or reconstruction is planned.

#### Flood Plain Management

Land use regulations within the 100-year flood plain would be beneficial in preventing floodwater and sediment damages from occurring along undeveloped portions of Alkali Creek above Highway 87. Very few houses or businesses are currently located in or near the 100-year flood plain. A comprehensive plan would be adopted by the City of Billings and Yellowstone County for this area.

Flood plain regulations would have beneficial environmental effects. Prevention of urban encroachment on the Alkali Creek flood plain would protect the existing flood channel and preserve wildlife habitat in its present condition. Opportunities for open space and park development would be enhanced.

Flood plain regulations alone would not provide needed floodwater protection of the Yellowstone County Fairgrounds.

#### Flood Plain Insurance

Flood plain insurance could offset some flood losses. However, this alternative would do nothing to stop pollutants, filth, and debris from being washed into the damage area or the Yellowstone River. The large fixed investment in the Yellowstone County Fairgrounds and surrounding area would be depreciated. Potential loss of life, personal property loss, and safety hazards to people would still prevail.

Relocation

Relocation of the Yellowstone County Fairgrounds and surrounding commercial development would cost in excess of \$50,000,000 and was not considered feasible.

Install No Flood Protection

The magnitude of public and private investment and potential loss in the damage area must be considered with this alternative. Potential loss of life, personal property loss, and safety hazards to people would still prevail. This alternative is considered invalid since feasible means of flood protection can be provided.

S E L E C T E D      P R O J E C T      M E A S U R E S

Land Treatment

Land treatment measures were selected to maintain the good to excellent rangeland condition and proper use of cropland. Land treatment measures will be needed to minimize sediment and erosion in the lower watershed as more urban development takes place. Land treatment measures will help create a more esthetically pleasing environment and additional recreational opportunities.

Structural Measures

The primary consideration in selecting project measures was to provide needed flood protection to the Yellowstone County Fairgrounds and adjacent commercial areas. Emphasis was given to: (1) assuring a high level of flood protection; (2) providing recreational opportunities; (3) minimizing adverse environmental impacts; and (4) minimizing construction and land rights costs.

A bypass channel was selected as the most practical means to achieve the desired flood protection for the Yellowstone County Fairgrounds and adjacent areas. This alternative is suited for existing and future development of the fairgrounds, City of Billings waste water treatment plant, and adjacent area. Additional benefits will be obtained from filling the abandoned Alkali Creek channel and gaining use of a valuable contiguous area within the fairgrounds. This alternative will have a minimum of adverse environmental impacts. Limited opportunities will be provided for recreational development and fishing along the lower channel. A bypass channel and diversion dam is the least costly alternative to meet the sponsors' objectives. See Photo Plate 7 for panoramic view of the Yellowstone County Fairgrounds and adjoining area.

Flood Plain Management

Flood plain management was selected to minimize floodwater and sediment damages occurring along undeveloped portions of Alkali Creek from the proposed bypass channel upstream to the Five Fingers Lake site. Prevention of urban encroachment on the Alkali Creek flood plain would help protect the existing flood channel and preserve wildlife habitat in its present condition. See Figures 2-4 showing 100-year flood plain delineations. Information was incorporated from the U. S. Army Corps of Engineers for 3.1 miles of the 9.8 miles study area (channel distance).

PLATE 7



Panoramic view of Yellowstone County Fairgrounds showing location of Alkali Creek along with proposed Diversion Dam and Bypass Channel. The fairgrounds and adjoining commercial area will be protected from flooding by Alkali Creek with the proposed measures. Foundation excavation for the new Multipurpose Community Center has been completed. Construction of this building is in progress.

SCS Photo April 1973



W O R K S   O F   I M P R O V E M E N T

T O   B E   I N S T A L L E D

L A N D   T R E A T M E N T

Land treatment measures planned for rangeland and cropland in the watershed are aimed at improving and maintaining good vegetative cover and holding soil erosion at a practical minimum. Land treatment measures to be continued or installed include proper grazing use, range deferred grazing, stockwater development, and conservation cropping systems (stripcropping and crop residue management). Land treatment measures to be installed along lower reaches of the watershed and in urban areas include critical area plantings (seedings in urban areas), grassed waterways or outlets, heavy use area protection, and recreation area improvement. The estimated total cost of planning and applying needed land treatment measures is \$37,730.

Flood plain management of the delineated 100-year flood plain along Alkali Creek will be carried out in conjunction with other land treatment and structural measures. A detailed discussion pertaining to state and federal laws, recommended land uses, and limitations of the flood plain study are contained in Appendix A, Supplemental Flood Hazard Analyses Data.

S T R U C T U R A L   M E A S U R E S

Bypass Channel

A bypass channel on Alkali Creek will be located north of the fairgrounds and cut through a narrow rimrock bluff. A diversion dam will be constructed across Alkali Creek about 1,200 feet downstream from Highway 87. This diversion dam will be used to gather and direct flows of Alkali Creek into the new bypass channel. See Figure 1 and Project Map, Figure 5.

The bypass channel has a capacity to convey 15,000 cubic feet per second (cfs) and is designed to handle 7,200 cfs.

The bypass channel is planned to be 1,315 feet long. See Table 3A. Beginning at Alkali Creek below U. S. Highway 87, a level section, 750 feet long, will extend through the rimrock bluff. About 500 feet will be constructed in alluvial material. The next 250 feet will be excavated in massive sandstone. This section is planned as a control section to reduce flow velocities and upstream erosion.

A drop section and energy dissipating basin will be constructed in the massive sandstone at the southeast edge of the rimrock bluff. This section will be 200 feet long with a drop of 40 feet into the energy dissipating basin. The sandstone floor of the drop section will be paved with concrete to prevent weathering and subsequent erosion of the sandstone. The upper portion of the dissipating basin will be protected with rock riprap.

The final section of the bypass channel will be 365 feet long. It will be constructed in gravels and will connect the energy dissipating basin with the City of Billings outlet channel. Two 36-inch diameter drainage culverts with floodgates will be installed under the southeast dike to provide surface drainage outlets for the fairgrounds. The bottom of the channel will be level and at the same elevation as the bottom of the Yellowstone River. Planning of this channel section and the City of Billings outlet channel, which will be about 585 feet long, has been coordinated. The lower channel and dissipator basin will be water-filled throughout the year. Tailwater conditions will be maintained in the dissipating basin for all flow conditions. The lower channel freeboard elevation is based on the Yellowstone River being at the U. S. Army Corps of Engineers Standard Project flood stage during a 15,000 cfs discharge in Alkali Creek.

A diversion dam, 850 feet long, is required to divert Alkali Creek flows into the bypass channel. The diversion dam is planned as a zoned fill with an impervious core. The dam will have a freeboard capacity for the probable maximum flood event. The dam will be about 31 feet high and have a minimum top width of 20 feet. A short section of existing county road will be raised to form a trail dike connecting the diversion dam with U. S. Highway 87. A pump and pipeline over the dam is planned to maintain water rights downstream. Land rights negotiations may eliminate the need for this pumping system. The diversion dam could be used to provide access to the northern part of the fairgrounds.

The construction of the bypass channel and diversion dam will require 12.1 acres of land, including 5.1 acres of potential borrow area. Yellowstone County now owns 11.5 acres and 0.6 acre is privately owned. Negotiations are under way by Yellowstone County for the acquisition of the privately owned parcel of land. Land used for project construction will include 4.9 acres of rimrock bluff, developed fairgrounds area, roads, and railroads, and 7.2 acres of modified valley bottom lands along Alkali Creek.

Rock excavated from the bypass channel will be used for shell material on the diversion dam and for riprap around the dissipating basin. Borrow material will be taken from suitable channel excavation to minimize the amount of disturbed area. Potential borrow areas will

be used only if quantities of excavated material from the channel are inadequate or unsuitable for fill material. Excess excavation will be used to fill the abandoned channel of Alkali Creek and widen the base of the diversion dam.

Borrow areas and the filled abandoned channel will be graded, shaped, and vegetated with adapted vegetation following project construction.

A chainlink-type fence will be constructed along both sides of the cut portion of the bypass channel to provide for public safety.

The project will require the relocation of two buried telephone cables and two overhead telephone lines owned by Mountain Bell Telephone Company, one municipal water line, one natural gas line owned by Montana-Dakota Utilities Company, and one county building. Overhead power lines owned by Montana Power Company in the construction area will not require relocation. Permission to work under the lines will be needed.

A railroad spur owned by Burlington Northern Inc. now crosses the proposed bypass channel. A railroad bridge may be required to span the channel or the spur line may be abandoned. Negotiations are under way between Burlington Northern officials and Yellowstone County to resolve this matter. This plan includes the higher cost alternative of a railroad bridge as a land rights cost.

Investigations indicate that project construction will not affect any known archeological or historical site. The Montana Statewide Archeological Survey of the Department of Anthropology, University of Montana, Missoula, Montana, is the state agency responsible for surveying archeological features. This agency has examined the Alkali Creek Watershed and reports that project construction will not affect known archeological features.

The Recreation and Parks Division, Department of Fish and Game, State of Montana, is responsible for the investigation of cultural and historic aspects and through consultation has indicated there are no items of significance within the project area.

In the event evidence of archeological, historical, scientific, or prehistorical material is uncovered during construction, the Secretary of the Interior, National Park Service, and administrators of the above-mentioned state agencies will be notified.

The estimated construction cost of the bypass channel and diversion dam is \$243,800.

## E X P L A N A T I O N    O F    I N S T A L L A T I O N    C O S T S

### LAND TREATMENT MEASURES

Installation cost of land treatment measures as shown in Table 1 totals \$37,730. This includes \$20,080 for land treatment in the lower watershed and urban areas and \$17,650 for measures to be installed on rangeland and cropland in the upper watershed.

### STRUCTURAL MEASURES

Total cost of structural measures includes construction, engineering services, land rights, and project administration. All installation costs are allocated to flood prevention.

#### Construction

The total construction cost for the project is estimated at \$243,800. The construction cost of the diversion dam includes clearing rights-of-way, construction of the diversion dam, and shaping and seeding of disturbed areas. The construction cost of the bypass channel includes clearing of rights-of-way, construction of dikes, excavation of the channel, and shaping and seeding of disturbed areas. A contingency allowance of 15 percent is included to allow for unforeseen costs. See Tables 1 and 2.

#### Engineering Services

The cost of engineering services, estimated at \$29,250, includes the direct cost of engineers and other technicians for surveys, investigations, design, and preparation of plans and specifications for structural measures, including associated vegetative work.

#### Project Administration

Project administration cost, estimated at \$56,000, includes contract administration, review of engineering plans prepared by others, government representatives, construction surveys, and all necessary inspections during construction that are required to ensure installation of structural measures in accord with plans and specifications.

#### Relocation Payments

The acquisition of lands required for the project will not necessitate the relocation of any person, business, or farm operation. No relocation cost is foreseen.

### Land Rights

Total land rights cost for the diversion dam and bypass channel is estimated at \$321,000. This amount includes \$56,000 for 7.0 acres of land containing structural measures; \$25,500 for 5.1 acres of borrow area; \$152,000 for 190 feet of railroad bridge; \$10,000 for 2,000 feet of protective fence along the bypass channel; \$40,000 for relocating one municipal water line; \$10,000 for relocating two telephone lines and two buried cables; \$2,500 for a pump and pipeline system to maintain existing water rights; and \$25,000 for moving one county building.

### COST SHARING

Installation costs will be shared between local sponsors and the federal government according to the requirements of Public Law 566 as amended and the Policy Statement of the Secretary of Agriculture. All construction and engineering service cost will be borne by Public Law 566 funds. Land rights costs will be borne by other funds.

### Public Law 566 Funds

The following costs will be borne by Public Law 566 funds:

1. All construction cost, estimated at \$243,800
2. All engineering service cost, estimated at \$29,250
3. Project administration cost, incurred by the Service, estimated at \$51,120.

### Other Funds

The following costs will be borne by other than Public Law 566 funds:

1. All land rights cost for land purchases, protective fence, railroad bridge, utility relocation, and building moving, estimated at \$321,000.
2. Project administration cost, incurred by the sponsors, estimated at \$4,880.

### EXPENDITURES BY FISCAL YEARS

The estimated expenditures of funds by fiscal years is shown in the table on the following page.

OBLIGATION OF FUNDS BY FISCAL YEARS

Alkali Creek Watershed, Montana

	1st Year		2nd Year		3rd Year		4th Year	
	PL-566	Other	PL-566	Other	PL-566	Other	PL-566	Other
Land Rights	56,000		255,000				10,000	
Construction		243,800						
Engineering Services	20,000		9,250					
Project Administration			20,000	2,440	20,000	2,440	11,120	---
Subtotal	20,000	56,000	273,050	257,440	20,000	12,440	11,120	---
Land Treatment								
Cropland		130		130		130		120
Rangeland		3,620		3,620		3,620		3,640
Urban and Built-up		4,490		4,490		4,490		4,480
Technical Assistance		1,190		1,190		1,190		1,210
PROJECT TOTAL	20,000	65,430	273,050	266,870	20,000	21,870	11,120	9,450

## E F F E C T S   O F   W O R K S   O F   I M P R O V E M E N T

The principal effects of installing the Alkali Creek Watershed project will be: (1) the reduction of floodwater damages to the Yellowstone County Fairgrounds and businesses, streets, highways, and utilities in the adjoining commercial area in Billings; (2) the enhancement of opportunities for improvement and expansion of fairground facilities; and (3) the overall improvement of the environmental quality of the area.

### F L O O D   P R E V E N T I O N , E R O S I O N   A N D   S E D I M E N T

All flows from Alkali Creek will be diverted by the proposed diversion dam and bypass channel directly to the Yellowstone River. The bypass channel and diversion dam will control runoff from 40.8 square miles or 98.2 percent of the contributing area above the Yellowstone County Fairgrounds. The watershed project will eliminate floodwater and sediment damages to areas of eastern Billings from flood flows originating in the Alkali Creek Watershed. The runoff from about 460 acres of uncontrolled urban area west of and including the fairgrounds will cause minor flood damages and ponding of water in low places when storm sewer capacities are exceeded. Flood plain management is expected to minimize future floodwater damages to flood plain areas along Alkali Creek above the proposed structural measures.

Damages from the 100-year storm would be reduced from \$661,500 to \$4,000. Average annual damages over the life of the project would be reduced about 99 percent from \$46,930 to \$310. These residual damages will occur from uncontrolled local runoff. See Table 5. Damages below the bypass channel and diversion dam from Alkali Creek flows will be eliminated. Damages along Alkali Creek above the bypass channel and diversion dam will be unchanged.

Damages to more than 20 businesses will be reduced. The value of private and public property protected in Billings is estimated at over \$9,700,000.

Floodwaters diverted into the Yellowstone River through the bypass channel will have a minor effect on river stages.

The bypass channel and diversion dam will eliminate 4,500 feet of modified channel on Alkali Creek (6.7 acres of channel area). About 2.7 acres of channel area below the diversion dam will remain unaltered. This area will continue to provide small animal and bird habitat. The remaining 4.0 acres in the lower reach of the abandoned channel area will be filled. This will eliminate streambank erosion, littered stream channel, stagnant water, and a small amount of brushy habitat.

Land use changes in the watershed will be limited to areas involved in structural works. The diversion dam and bypass channel will require 6.4 acres of county-owned land and 0.6 acre of private land. An additional 5.1 acres of land along Alkali Creek near the bypass channel and diversion dam may be used for borrow area. Land use at the present time is: 7.2 acres of Alkali Creek flood plain; 1.8 acres of road fill and railroad spur right-of-way; 0.7 acre of sandstone terrace; 0.3 acre of steep rimrock bluffs; and 2.1 acres of alluvial bottom lands of the Yellowstone River. All these areas are immediately adjacent to urbanized areas.

Smoke, noise, dust, and sediment pollution will be experienced during construction. Land treatment measures will reduce sedimentation problems caused by increased urbanization of the lower watershed. Land treatment measures in the upper watershed will help maintain the good to excellent cover conditions and help hold erosion and sediment production at the lowest practical minimum.

FISH, WILDLIFE, RECREATION,  
AND VISUAL QUALITY

Installation of project measures will result in minor losses of wildlife habitat. About 3.2 acres of brushy streambank habitat and 1.0 acre of rimrock bluff and sandstone terrace will be destroyed. The outlet channel will be full of water at all times. This area (500 feet long by 75 feet wide) will provide habitat for fish and other aquatic life and opportunities for public fishing. The dikes on the edges of the outlet channel will be grassed and access will be provided for public use.

Land treatment measures will result in improved cover conditions and wildlife habitat in the watershed. Most of these measures will affect the lower watershed area which is under pressure due to urbanization.

Improved planting practices will improve the visual quality in the lower watershed. An improvement in visual quality will result when trash and debris are removed from the project area prior to construction. The finished structural works will alter visual aspects of the landscape.

ECONOMIC AND SOCIAL

The greatest effect of the project will be to protect people and property in the urbanized area of the lower watershed. Funds

normally expended to repair flood damages or for cleanup by Yellowstone County may be used to greater advantage by local citizens. Project construction will create 5.5 man-years of new employment.

Flood plain management will prevent a buildup of damageable values along Alkali Creek. Land use changes will be minor since most of the delineated flood plain area is within a deeply incised channel area. Flood plain management will help preserve habitat in a 200-acre area along Alkali Creek.

ARCHEOLOGICAL, HISTORICAL,  
AND SCIENTIFIC

Investigations indicate the project will not affect any known archeological, historical, scientific, or prehistorical materials in the watershed. In the event such materials are uncovered during construction, the Secretary of the Interior, National Park Service, and responsible state agencies will be notified.

## PROJECT BENEFITS

### PRIMARY BENEFITS

Average annual floodwater and sediment damage reduction benefits, over the life of the project, are estimated at \$46,620. See Table 5.

Direct floodwater damage reduction benefits are estimated at \$37,500 and include fairgrounds benefits of \$32,540; commercial benefits of \$4,730; and \$230 of benefits to city streets, storm sewers, and cleanup. These benefits will accrue in the 165-acre fairgrounds and adjoining commercial area.

There will be additional benefits resulting from the installation of project measures. Entertainment contracts which are made long in advance of the Yellowstone Exhibition in August will not be jeopardized by the disruption of a spring or summer flood. Utility lines that go through the fairgrounds will not be subjected to damage and interruptions. Traffic delays and detours will be prevented. Interruption of scheduled activities at the fairgrounds would be very costly. The schedules and orderly plans of many persons who would attend the Fair from outside the Billings area would be affected, particularly if a flood occurred just prior to Fair time. Many farmers and ranchers must make arrangements in advance for the transportation of livestock and other exhibits to the Fair. Average annual indirect floodwater damage reduction benefits are estimated at \$9,120.

Construction cost savings will accrue to the Multipurpose Community Center, now beginning construction, by eliminating the need for a large culvert or bridge at the south side approach ramp. Other cost savings will include utilizing the present channel to locate water and sewer lines before it is filled. The need for two bridges to serve the area near the new building will be eliminated. These cost savings, estimated at \$221,700, provide an average annual benefit of \$12,520. These cost savings will accrue only if project construction can be coordinated with the construction of the Multipurpose Community Center.

Project installation will result in a significant reduction of normal operation and maintenance costs at the Yellowstone County Fairgrounds. Less mosquito spray will be required in the fairgrounds since lower reaches of Alkali Creek will be filled. Expenditures for fairgrounds maintenance will be lowered with less weed mowing problems. Traffic control will be more efficient within the fairgrounds. Operation and maintenance costs will be reduced by an estimated \$2,670 annually.

Excess excavation material will be used to fill a portion of the abandoned channel near the Multipurpose Community Center. This will allow for more needed parking space and greater use of adjoining areas. An estimated 6.6 acres of channel area will be filled and reclaimed. An estimated eight acres of adjoining land will be enhanced. Land enhancement benefits are estimated at \$179,000 or an average annual benefit of \$10,110.

#### S E C O N D A R Y      B E N E F I T S

Secondary benefits are expected to accrue from project installation. Protection from flooding will allow for increased use and development of the fairgrounds. Secondary benefits will accrue to businesses in the benefited area. Increased demands are expected on transportation and other industries serving the benefited area. These secondary benefits are estimated at 10 percent of the direct flood-water damage reduction benefits or \$3,750. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation.

#### U N E V A L U A T E D      B E N E F I T S

The fairgrounds are used throughout the year for activities such as sports events, livestock shows, and sports shows. Damage reduction benefits do not include the prevention of property losses and possible loss of life that could occur from a flood during one of these events.

Other benefits will accrue to the community in the form of improved environmental conditions and enhancement of esthetic qualities of the lower reach of Alkali Creek. These benefits are recognized, but not evaluated.

C O M P A R I S O N      O F      B E N E F I T S      A N D      C O S T S

Average annual benefits from structural measures are estimated at \$75,670. Average annual costs of these structural measures are estimated at \$39,030. See Table 6.

The ratio of average annual benefits to average annual costs is 1.9 to 1.0. The ratio of benefits to costs without the inclusion of \$3,750 of local secondary benefits is 1.8 to 1.0. Benefits and costs for project measures are itemized in Tables 4, 5, and 6.

## PROJECT INSTALLATION

Structural and land treatment measures will be installed during a four-year installation period. Needed land treatment measures will be installed during this period to ensure optimum grazing land and dry cropland use. These measures will hold erosion, runoff, and sediment production to a minimum. Engineering services and the acquisition of land rights will begin in the first year. Construction of the Alkali Creek bypass channel and diversion dam will be carried out during the second and third years. Seeding and fencing of all structural measures will be done as soon as practical after construction or as conditions permit.

### INSTALLATION RESPONSIBILITIES

#### Land Treatment Measures

Land treatment measures will be installed on private lands by individual landowners and operators. The installation of land treatment measures will be continued throughout the life of the project. Technical assistance will be provided by the Yellowstone Conservation District.

The responsibilities of the District will include:

1. Encouraging the development and use of resource conservation plans on all lands in the watershed to create a showplace of soil and water conservation.
2. Providing leadership in the education program that will result in proper application of land treatment measures essential to the success of this project.

#### Flood Plain Management

A flood plain management program will be carried out by Yellowstone County for the area of the 100-year flood plain from the bypass channel upstream to the Five Fingers Lake site. This program will be developed as a part of the project agreement. Flood plain management of the hazard area will include public information programs, land use regulations, and promotion of green belt development along Alkali Creek. See Flood Hazard Analyses section and Flood Hazard maps, Figures 2-4.

#### Structural Measures

The installation of all structural measures will be the responsibility of Yellowstone County. The County will be responsible for

contract administration and for dealing with the SCS during construction and will establish a financial management system including provision for financial reporting meeting the requirements of General Services Administration (GSA) Federal Management Circular 74-7. Federal assistance for installing the structural works of improvement as described in this plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended. Under this authority the Soil Conservation Service will provide: (1) engineering services including surveys, site investigations, design, and preparation of plans and specifications; and (2) project administration, including review of engineering plans prepared by others, government representatives, construction surveys, and necessary inspection services during construction. Yellowstone County will furnish local representatives to review plans and construction as necessary to assure local interests are met.

The Sponsoring Local Organization shall meet the following conditions for each portion of construction before issuance of invitations to bid on that unit of construction:

1. Land rights will be assured by Yellowstone County. The Sponsors have sufficient legal authority to acquire the needed land rights and agree to use such authority if necessary.

The acquisition of all lands, easements, or rights-of-way shall be made in compliance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, PL-91-646, and appurtenant USDA and federal regulations. These provide that in cases where land rights are not obtained by donation or land exchange, every reasonable effort will be made to acquire real property rights by negotiation. Prior to the initiation of negotiations, an appraisal of the fair market value of the real property interest will be made by a qualified land appraiser.

2. Mutual agreement shall be reached on the schedule for construction and on plans and specifications. Terms of contracts and all matters pertaining to such contracts shall be mutually satisfactory and in accord with administrative and technical requirements governing the local sponsors and the Soil Conservation Service.
3. Full conformance with local, state, and federal laws shall be the responsibility of the local sponsors. Reasonable evidence of such conformity shall be provided to the mutual satisfaction of all parties at no expenditure of Public Law 566 funds.

## METHODS OF INSTALLATION

The contracts for the construction of structural measures will be let on a competitive bid basis.

Contractors will be required to follow regulations to prevent sedimentation and pollution of stream waters during construction. Provisions will be made to save topsoil material and spread it over all areas to be seeded. Dust control during construction will be required. Contractors will also be required to provide protection against the effects of excessive noise exposure. All SCS safety requirements for construction will be strictly observed.

It will be the mutual responsibility of Yellowstone County and the Soil Conservation Service to coordinate pertinent designs, schedules, and construction of this project with other City and County projects planned for the fairgrounds area.

## FINANCING PROJECT INSTALLATION

Project costs to be shared by Public Law 566 funds will be paid out of funds appropriated under the authority of Public Law 566, 83d Congress, 68 Stat. 666, as amended. This work plan does not constitute a financial document for obligation of either federal or other funds, including those of local sponsors. Financial or other assistance to be furnished by the Service in carrying out the plan is contingent on the appropriation of funds for this purpose. Program income shall be handled in accordance with GSA Federal Management Circular 74-7.

Yellowstone County is a legally constituted organization under Montana law. The County has the power to borrow money for financing the installation of this project, the power of eminent domain, and the power to levy taxes for repayment of borrowed funds and payment of operating expenses.

### LAND TREATMENT

The cost of applying land treatment on private land will be borne by individual landowners or operators in conjunction with assistance as may be provided under ongoing agricultural programs. Technical assistance for land treatment will be provided by the Yellowstone Conservation District in cooperation with the Soil Conservation Service from ongoing program funds available at the time of planning and installation.

### STRUCTURAL MEASURES

Installation costs other than those allocated to Public Law 566 funds will be the responsibility of Yellowstone County. Yellowstone County will finance its share of costs from locally available funds. Local project costs are estimated at \$325,880.

P R O V I S I O N   F O R   O P E R A T I O N ,  
M A I N T E N A N C E   A N D   R E P L A C E M E N T

L A N D   T R E A T M E N T

Land treatment measures will be operated and maintained on private land by individual owners and operators in cooperation with the Yellowstone Conservation District.

S T R U C T U R A L   M E A S U R E S

The operation and maintenance of the bypass channel and diversion dam shall be the responsibility of Yellowstone County in compliance with operation agreements satisfactory to the local sponsors and the Soil Conservation Service. An operation and maintenance agreement will be executed prior to signing of a Land Rights or Project Agreement in accordance with the SCS Montana Watersheds Operation and Maintenance Handbook. This operation and maintenance agreement will include provision to coordinate operation and maintenance activities with the City of Billings as pertains to the City's outlet channel.

The operation of structural measures shall include, but not be limited to:

Operating the bypass channel as an unrestricted free-flowing channel to permit passage of all flows.

The maintenance of structural measures shall include, but not be limited to:

1. Keeping all structures in serviceable condition by replacement and repair as needed during the life of the project.
2. Keeping all surface water inlets, culvert(s) under U. S. Highway 87, bridges across the bypass channel, clear of debris and restrictions.
3. Maintaining or replacing protective vegetative cover, riprap, and fences as needed.

Operation and maintenance costs include items normally expected as repairs and upkeep on the structural measures. Annual operation, maintenance, and replacement costs are estimated at \$2,310 and will be the responsibility of Yellowstone County. See Table 4.

A Service employee, responsible for operation and maintenance inspections and followup, and the local sponsors will make a joint

inspection annually, after severe storms, and after the occurrence of any other unusual conditions that might adversely affect the structural measures. These inspections will continue annually during the establishment period (three years) following installation of each structure. Particular attention will be given to problems that might arise concerning scour in the bypass channel or failure of the riprap downstream from the energy dissipating basin. The Service will initiate action to correct any deficiencies noted during the establishment period. Inspections after the third year will be made annually by the local sponsors and a written report of conditions and recommended actions will be submitted to the Service employee responsible for seeing that operation and maintenance are carried out. In situations where the sponsors have shown lack of ability to carry out inspections properly, or there is an indication of need for continued Service assistance, the Service may continue to provide assistance after the third year at the discretion of the State Conservationist.

The Service employee responsible for operation and maintenance inspections and followup will thoroughly review the sponsors' inspection, operation, and maintenance reports. Evidence that inspections or needed maintenance are not being performed properly and promptly will be reported to the State Conservationist, who must then take appropriate action on reported deficiencies.

TABLE 1--ESTIMATED PROJECT INSTALLATION COST

Alkali Creek Watershed, Montana

Installation Cost Item	Unit	Non-Fed. Land	SCS <u>2/</u>	Estimated Cost (Dollars) <u>1/</u>		
				PL-566 Funds	Other Funds	Non-Fed. Land
				Non-Fed. Land	Non-Fed. Land	Total
<u>LAND TREATMENT</u>						
Land Area						
Cropland	Ac.	2,990		510		510
Rangeland	Ac.	20,810		14,500		14,500
Urban and Built-up	Ac.	2,800		17,950		17,950
Technical Assistance				4,770		4,770
TOTAL LAND TREATMENT				37,730		37,730
<u>STRUCTURAL MEASURES</u>						
Construction						
Diversions Dam & Bypass Channel	<u>3/</u>	Ft.	1,315	243,800		243,800
Engineering Services				29,250		29,250
Project Administration						
Construction Inspection				31,700		31,700
Other--Overhead				17,000		17,000
Contract Administration				2,420		2,420
Subtotal Project Administration				51,120		51,120
Other Costs				4,880		4,880
Land Rights						321,000
TOTAL STRUCTURAL MEASURES				324,170		325,880
TOTAL PROJECT				324,170		363,610
						687,780

1/ Price Base 1974; 2/ Federal agency responsible for assisting in installation of works of improvement; 3/ Channel Type "M" (man-made ditch or previously modified channel).

March 1974

TABLE 1A--STATUS OF WATERSHED WORKS OF IMPROVEMENT  
Alkali Creek Watershed, Montana

Measures	Unit	Applied to Date	Total Cost (Dollars) <sup>1/</sup>
<u>LAND TREATMENT</u>			
Conservation Plans	No.	8	4,480
Conservation Cropping System (Stripcropping)	Ac.	2,880	750
Crop Residue Management	Ac.	2,880	490
Proper Grazing Use	Ac.	21,000	210
Deferred Grazing	Ac.	21,000	210
Ponds	No.	13	17,420
Wells	No.	13	27,090
Farmstead Windbreak	Ac.	6	770
Recreation Trail & Walkway	Ft.	1,500	810
		TOTAL	<u>52,230</u>

<sup>1/</sup> Price Base 1973

March 1974

TABLE 2--ESTIMATED STRUCTURAL COST DISTRIBUTION

Alkali Creek Watershed, Montana

(Dollars) 1/

Item	INSTALLATION COST: PL-566 FUNDS			INSTALLATION COST: OTHER FUNDS		
	Construction	Engineering	Total	PL-566	Land Rights	Total
<u>STRUCTURAL MEASURES</u>						
Bypass Channel and Diversion Dam	243,800	29,250	273,050		321,000 <sup>2/</sup>	321,000
Subtotal	243,800	29,250	273,050	321,000	321,000	594,050
Project Administration	---	---	51,120	---	4,880	56,000
<b>GRAND TOTAL</b>	<b>243,800</b>	<b>29,250</b>	<b>324,170</b>	<b>321,000</b>	<b>325,880</b>	<b>650,050</b>

March 1974

1/ Price base 1974

2/ Includes \$56,000 for seven acres of land; \$25,500 for 5.1 acres of potential borrow area; \$152,000 for 190 feet of railroad bridge; \$10,000 for 2,000 feet of protective fence; \$40,000 for relocating one municipal water line; \$10,000 for relocating two telephone lines and two buried cables; \$2,500 for pump and pipeline system (maintain existing water rights); \$25,000 for relocating one county building.

TABLE 3A--STRUCTURAL DATA--CHANNELS

## Alkali Creek Watershed, Montana

## B Y P A S S C H A N N E L 1/

Station	Design Capacity <sup>2/</sup> cfs	Water Surface Elevation 10-Yr. Q=1860 cfs	Channel Dimensions			"n" Value Aged	As Built	Velocities (Ft/Sec) 10-Yr. Q = 1860 cfs As Built
			Bottom Width	Side Width	Slopes			
19+00	7200	3083.00	50	2:1	0.035	0.025	4.15	4.16
17+00	7200	3083.19	50	2:1	0.035	0.025	4.02	4.10
15+00	7200	3083.37	50	2:1	0.035	0.025	3.90	4.03
13+00	7200	3083.54	50	2:1	0.035	0.025	3.79	3.96
11+00	7200	3083.69	50	2:1	0.035	0.025	3.70	3.90
9+50	7200	3083.80	50	2:1	0.035	0.025	3.64	3.86
DROP								
7+10	7200	3120.82	40	½:1	0.035	0.025	9.11	9.56
7+00	7200	3120.96	40	½:1	0.035	0.025	8.83	9.36
6+50	7200	3121.40	40	½:1	0.035	0.025	8.50	9.06
6+00	7200	3121.83	40	½:1	0.035	0.025	7.44	8.15
5+80	7200	3122.00	40	½:1	0.035	0.025	7.21	7.93
5+20	7200	3122.22	40	½:1	0.035	0.025	6.94	7.68
5+00	7200	3122.77	50	2:1	0.035	0.025	4.32	4.78
4+20	7200	3122.78	50	2:1	0.035	0.025	4.31	4.73
3+80	7200	3122.83	50	2:1	0.035	0.025	4.28	4.70
3+00	7200	3122.92	50	2:1	0.035	0.025	4.21	4.65
2+00	7200	3123.02	50	2:1	0.035	0.025	4.14	4.58
1+00	7200	3123.12	50	2:1	0.035	0.025	4.07	4.52
0+00	7200	3123.22	50	2:1	0.035	0.025	4.00	4.47

1/ Type of work I; "new channel" replaces and realigns existing modified channel  
 Before project--channel type M (1900 to 1974), Flow condition Pr  
 2/ 100-year discharge--7200 cfs (freeboard discharge--15,000 cfs)

March 1974

TABLE 4--ANNUAL COST

## ALKALI CREEK WATERSHED, MONTANA

(Dollars)<sup>1/</sup>

Evaluation Unit	Amortization of Installation Cost <sup>2/</sup>	Operation, Maintenance, & Replacement Cost	Total
Diversion Dam & Bypass Channel	33,560	2,310	35,870
Project Administration	3,160		3,160
GRAND TOTAL	36,720	2,310 <sup>3/</sup>	39,030

March 1974

1/ Price Base 19742/ 100 years, 5-5/8 percent3/ Includes \$1,700 average annual replacement cost for rock riprap.

TABLE 5--ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Alkali Creek Watershed, Montana  
 (Dollars) <sup>1/</sup>

Item	Estimated Average Annual Damages		Damage Reduction Benefits	
	Without Project	With Project		
<u>Floodwater and Sediment</u>				
<u>Non-Agricultural</u>				
Fairgrounds	32,770	230	32,540	
Commercial	4,750	20	4,730	
City--streets, storm sewers, cleanup	230	---	230	
Subtotal	37,750	250	37,500	
Indirect	9,180	60	9,120	
Total	46,930	310	46,620	

March 1974

1/ Price Base 1974

TABLE 6--COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

ALKALI CREEK WATERSHED, MONTANA

(Dollars)<sup>1/</sup>

Damage Reduction	AVERAGE ANNUAL BENEFITS			Average <sup>2/</sup>		Benefit to Cost Ratio	
	Cost Savings	Land Enhancement	Secondary	Total	Annual Cost		
Bypass Channel and Diversion Structures	46,620	15,190	10,110	3,750	75,670	35,870	2.1 to 1.0
Project Administration						3,160	
GRAND TOTAL	46,620	15,190	10,110	3,750	75,670	39,030	1.9 to 1.0
							March 1974

<sup>1/</sup> Price Base 1974  
<sup>2/</sup> From Table 4



## INVESTIGATION AND ANALYSES SECTION

### GEOLOGY

#### METHODS AND SCOPE OF INVESTIGATIONS FOR STRUCTURES

Geologic investigations were conducted for the potential structure sites considered in the formulation of this watershed work plan. Available geologic maps and reports were reviewed. Field examinations of surface features were conducted. Preliminary auger and rock core borings were used to evaluate subsurface conditions at selected sites.

#### Five Fingers Lake Dam

Subsurface investigations of the proposed dam site, borrow areas, and emergency spillway site consisted of borings by a B-40 Mobile drill. Borings extended to bedrock where possible. All materials were field classified according to the Unified Classification System. Geologic profiles were prepared for the dam centerline and the emergency spillway control section.

Ten subsurface borings were located along the proposed dam centerline. Analysis of the subsurface data indicated that the dam would be founded on alluvial materials overlying shale bedrock. The alluvial materials consist of up to six feet of silty sand overlying clays of variable composition and density. Investigations indicate approximately 20 feet of stripping to shale bedrock would be required. The abutment areas consist of massive sandstone with widely spaced joints. Surface observations indicate that the joints are tightly sealed. The sandstone is pervious and minor leakage can be expected.

The proposed borrow area and emergency spillway site were investigated with auger borings located on a modified grid system. Abundant quantities of silty clay (CL-2) borrow materials are located near the site. Drain materials and riprap would have to be imported. Flow velocities through this spillway would have to be low to prevent serious erosion. The emergency spillway would be excavated into shale bedrock of variable hardness.

#### Diversion Dam and Bypass Channel

Investigations for the diversion dam and bypass channel were completed by surface and limited subsurface investigations. Seven subsurface borings were located along the proposed bypass channel centerline. Alluvial portions of the channel alignment were drilled

with hollow stem auger. Standard penetration resistance tests were conducted about every five feet. Channel alignment in the sandstone rimrock bluff was evaluated by rock core drilling. Samples were collected and examined for competence and fracturing. The cores collected indicate the rimrock bluff is composed of massive, medium-grained cemented sandstone. The rock is moderately hard and pervious. Drilling and blasting will be required for excavation of most of the sandstone. The sandstone will resist short duration high flow velocities without noticeable erosion. A protective pavement will be required to prevent rapid weathering in areas subject to frequent wetting and drying by normal Alkali Creek flows.

Suitable alluvial materials excavated from the bypass channel will be used to construct the diversion dam. Quantities of impervious materials are limited in the cut section. Additional impervious borrow is available in flood plain deposits adjacent to Alkali Creek.

A drop section and stilling basin will be excavated into the massive sandstone. Portions not continually under water will require paving. The sandstone portion of the stilling basin will be under water at all times and will not require protection. The upper 12 feet of the stilling basin will be excavated in alluvial materials. The alluvium will be protected with sandstone riprap. The riprap will have a projected maximum life of approximately 25 years.

The outlet section of the bypass channel will be constructed primarily in sandy gravels with cobbles. The lower portion of the channel will be excavated under submerged conditions. Excavated materials will be used to construct dikes. Excess materials will be used to fill in part of the abandoned section of the Alkali Creek channel. The diversion channel materials will be stable for the one percent discharge flow velocities.

#### Additional Investigations Needed for Construction

If the Five Fingers Lake dam is considered for construction, additional subsurface investigations will be needed. The sandstone abutments would need to be pressure tested to determine seepage rates and to evaluate the need for special design features to minimize seepage.

Foundation conditions should be evaluated by detailed subsurface investigations and sampling. Representative undisturbed samples should be tested to determine structural stability. Several deep holes should be drilled to determine bedrock composition and structure.

The bypass channel alignment will need to be investigated in detail to confirm alluvial and bedrock contacts. This information is required to refine excavation costs and locations of structural works.

The configuration of the channel bottom and specifications for concrete paving will be determined in final design after rock durability tests have been completed.

A series of drill holes and borrow pits will be needed to evaluate the composition and quantity of borrow materials for construction of the diversion dam. Bore holes are needed to determine foundation conditions under the diversion dam. This information is needed to determine excavation and fill quantities and to ensure foundation stability.

#### Sediment Investigations

Sediment and erosion rates were determined from a field reconnaissance study, use of aerial photos, and a review of available soil survey data. The study indicates sheet and gully erosion is the primary source of sediment. The gully erosion occurs in the Claggett shale areas of the upper watershed. Small areas of streambank erosion were observed along some modified stream reaches of the lower watershed. The amount of sheet erosion was determined by computations based on a modified Musgrave formula which employs factors of slope, land use, soil erodibility, and maximum 30-minute, two-year frequency precipitation. The sediment yield from all sources is about 0.14 acre-foot per square mile per year.

The area above the dam site is primarily native rangeland. Most of the needed land treatment measures have been installed; therefore, present and future rates of erosion and sedimentation are considered about equal.

Storage ponds suitable for sediment surveys are not present in the watershed. Detailed pond surveys were not conducted in adjacent areas outside the watershed because of the low computed sediment rate. At the dam site, 654 acre-feet were allocated for 100-year sediment storage. The sediment pool was planned to be wet and a unit weight of 60 pounds per cubic foot of sediment was used. This figure was based on samples from ponds of similar sediment character. Trap efficiencies and delivery rates were calculated using standard SCS methods.

## ENGINEERING

### SURVEYS AND INVESTIGATIONS

Topographic data for structural measures and flood plain delineation were obtained from: (1) topographic maps of the fairgrounds area prepared by Christian, Spring, Sielbach and Associates for Yellowstone County; (2) U. S. Geological Survey 7.5-minute quadrangle maps; (3) flood plain information prepared by U. S. Army Corps of Engineers<sup>3/</sup>; and (4) engineering field surveys conducted by SCS personnel. Vertical control is based on mean sea level datum.

U. S. Geologic Survey (USGS) quadrangle maps were used to develop stage-storage curves, stage-reservoir area curves, and emergency spillway excavation volumes for the Five Fingers Lake site. Embankment volumes were determined from a topographic survey of the dam site. Profiles and cross sections were surveyed by SCS personnel along Alkali Creek from the Yellowstone River upstream to the Five Fingers Lake site. These surveys were coordinated with flood data from the U. S. Army Corps of Engineers. Topographic maps prepared by Christian, Spring, Sielbach and Associates were used to determine location, profiles, and cross sections for design of channel alternatives and to estimate embankment and excavation volumes. Field surveys were made for location and elevations of bore holes along the proposed channel.

Hydrologic data developed for the watershed were used in selection and design of structural measures. These data were used to: (1) determine reservoir requirements; (2) determine capacities of principal and emergency spillways; (3) size dams, dikes, and channels; and (4) analyze effects of structural measures.

Geologic and engineering soils data were used for design of structural measures. These data were used to: (1) select sites for structural measures; (2) determine embankment slopes; (3) determine foundation excavation quantities; (4) locate borrow areas; (5) select channel cross sections and side slopes; (6) estimate life of riprap; and (7) estimate quantities and cost of excavation for rock and earth.

#### Selected Structural Measures

Design and proportions for structural measures to divert Alkali Creek above the fairgrounds were determined in consultation with SCS

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<sup>3/</sup> U. S. Army Corps of Engineers, "Flood Plain Information, Billings Metropolitan Region, Montana," Volume I, Yellowstone River and Volume II, Alkali Creek. October 1969.

specialists of Technical Service Center and state staff. The diversion dam was planned using standard engineering criteria. The diversion dam was designed with an impervious core with side slopes of 1:1 and a rock shell. An upstream slope of 3:1 and a downstream slope of 2:1 were selected for stability. The top elevation of the dam was determined using water surface profiles developed for the probable maximum storm. A minimum top width of 20 feet is required and was used for embankment computations.

The foundation preparation will consist of stripping the site and constructing a key trench into alluvial materials. Embankment material will be obtained from channel excavation. Additional impervious borrow is available from flood plain deposits near the dam. No special foundation preparation problems are anticipated.

Design and proportions of the bypass channel were based on criteria from SCS TR-25 and water surface profiles from hydraulic analysis. The 10-year flow is 1860 cfs and the 100-year flow is 7200 cfs. The bypass channel freeboard was determined using the U. S. Army Corps of Engineers Standard Project Flood (15,000 cfs), approximately a 500-year occurrence. The bypass channel is stable, using TR-25 data, for the 10-year storm. Geologic and soils information indicates that slopes of 2:1 in earth and gravel sections and 1/2:1 in rock sections will be stable. See data in Table 3A.

#### Other Alternatives

Design and proportions of structural measures at the Five Fingers Lake site were determined in consultation with Regional SCS soil mechanics specialists and SCS state specialists. Alternative solutions for design of both dams were developed to determine least costly alternatives. An upstream slope of 3:1 with a berm 10 feet wide at the elevation of the principal spillway inlet and a downstream slope of 2:1 with a berm 10 feet wide at the midpoint were selected for computing embankment volume. The upstream slope would be protected by rock riprap from an elevation six feet below to four feet above the elevation of the principal spillway inlet.

The foundation preparation would require excavation of questionable material below the base of the dam to depths up to 20 feet. Emergency spillways would be excavated in the right abutment. Impervious core material would be obtained from the reservoir basin.

Principal spillways would be located on compacted fill. Drop inlets would be standard risers with trash racks, adequate for watershed conditions. Thirty-inch principal spillway barrels meeting AWWA-301 specifications, placed on standard A-1 cradles with antiseep collars and impact basins were selected. Chute spillways were considered in the alternatives. Spillways were designed according to criteria of Engineering Memorandum No. 27 (Revised).

A rectangular concrete channel was selected for improving existing Alkali Creek channel through fairgrounds due to limited right-of-way, magnitude of flow, and needed grade control. The channel was proportioned using criterion from National Engineering Handbook, Section 14, Chute Spillways.

## H Y D R O L O G Y

Basic procedures used in hydrologic investigations are outlined and described in the National Engineering Handbook, Section 4, "Hydrology," and comply with the criteria in engineering memoranda.

Hydrologic studies were primarily concerned with: (1) determining flood levels along the lower reaches of Alkali Creek for a variety of frequency storm events in the Alkali Creek drainage; (2) determining the effects of a combination of a proposed structure at the Five Fingers Lake site, along with land treatment measures and channel improvements on flood peaks, flood levels, and runoff volumes; and (3) computing and routing design hydrographs to size the floodwater diversion structure and bypass channel.

### BASIC DATA AVAILABLE

Precipitation and temperature data were obtained from the U. S. National Weather Service records for the climatological station at Billings, Montana, from 1934 to 1973. Precipitation and temperature data were also obtained for eight other U. S. National Weather Service stations surrounding the Alkali Creek drainage.

Surface water data from gaging stations are not available in the watershed. Fourteen crest-stage gages and five water-stage recorder stations in the general area provided water yield and peak flow data which represented conditions in the watershed. These records were gathered and published by the U. S. Geological Survey. Drainage areas for the nineteen gaged streams used vary from 1.36 square miles to 435 square miles. The stations have periods of record starting as early as 1911 to as late as 1963.

Soil and cover data available include soil survey maps and cover conditions compiled by Soil Conservation Service.

Topographic data available during early planning stages were USGS 7.5-minute quadrangles and USGS 1:12,000 stereoscopic photography taken in 1972. Additional topography was developed from surveys by SCS personnel, U. S. Army Corps of Engineers, and Christian, Spring, Sielbach and Associates.

Local flood data included good photographs of damage done by flooding on June 11, 1937, as well as numerous newspaper articles covering other flood events.

## INVESTIGATIONS AND ANALYSES

### Historical Peak Flow and Annual Yield Frequency Studies

Peak flows correlated with the Hydrology TR#20 computer evaluation.

Annual peak flow-frequency relationships using the Log Pearson III methods were developed for the fourteen crest-stage stations selected and the five water-stage stations. A plot of the drainage areas versus csm rates for different frequencies was used to check the TR#20 computer program results.

Annual yield-frequency relationships were developed from the fourteen water-stage station records selected to determine reliability of a water supply for possible recreational use in the Five Fingers Lake reservoir. Annual yield was found to be inadequate to maintain the recreational pool.

### Drainage Areas, Times of Concentration, and Runoff Curve Numbers

Drainage areas were planimetered from areas delineated on U. S. Geological Survey 7.5-minute quadrangle maps. Channel and flood plain distances were also measured from these maps.

Times of concentration were computed using the USGS maps. The Curve Number Method was used for the Five Fingers Lake dam site. The Upland Method was used for computing times of concentration on the uncontrolled subareas. Runoff curve numbers were based on weighted averages of the soil-cover condition for each area and subarea. Future conditions were considered in developing curve numbers.

Drainage areas and times of concentration computed were used in a TR#20 computer evaluation of the Five Fingers Lake dam and bypass channel and the bypass channel alone.

### Flood Routings

Water surface profiles were computed for Alkali Creek from the Five Fingers Lake site to the Yellowstone River using the WSP-2 computer program. Water surface profiles in the proposed bypass channel were developed using computer programs.

The diversion dam and bypass channel were designed for stability using the ten percent chance peak (1860 cfs). The freeboard hydrograph for the diversion dam was determined using methods prescribed in NEH Section 4, "Hydrology." The bypass channel freeboard discharge (15,000

cfs) used was the U. S. Army Corps of Engineers Standard Project flood. It exceeds the 1937 flood peak (13,000 cfs), which was approximately a 500-year occurrence.

Water surface profiles were run in the bypass channel using a range of water surface elevations in the Yellowstone River to determine backwater effects. Yellowstone River stages used included the lowest on record (elevation 3,083 ms1) and ranged upward to the U. S. Army Corps of Engineers Standard Project flood (elevation 3,098 ms1). Required tailwater was maintained on the energy dissipating basin for all Yellowstone River stages checked.

Water surface profiles were computed for Alkali Creek using surveyed cross sections at selected intervals between the Five Fingers Lake site and the Yellowstone River. The results of the WSP-2 run correlated well with water surface profiles run by the U. S. Army Corps of Engineers on a 3.1-mile reach of lower Alkali Creek.<sup>4/</sup>

The Hydrology TR#20 computer program was used to model the watershed. Flooding conditions, both existing and with the proposed Five Fingers Lake reservoir, were determined for the 2-, 10-, 25-, and 100-year 24-hour storms.

The results of these evaluations are:

1. The csm rate analysis compared well with the regional analysis of stream gage records.
2. Flood levels along Alkali Creek obtained from the analysis compared well with the U. S. Army Corps of Engineers data, historical data, and photographs of local flooding. An abbreviated flood hazard analysis was prepared in conjunction with this report.
3. The Five Fingers Lake site would not provide the desired flood protection to the fairgrounds because of the remaining large uncontrolled drainage area. A bypass channel would be required in addition to the Five Fingers Lake dam.
4. Annual yield from Alkali Creek was not high enough to maintain a recreational reservoir at the Five Fingers Lake site.

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<sup>4/</sup> U. S. Army Corps of Engineers, "Flood Plain Information, Billings Metropolitan Region, Montana," Volume II, Alkali Creek. October 1969.

5. The proposed diversion dam and bypass channel provided 100-year protection to the fairgrounds and bypassed the 100-year peak with nonerosive flows. Additional flood protection is provided up to near the 500-year peak discharge, but flows in the bypass channel would be erosive.
6. Local flooding from the uncontrolled area below the diversion dam was impractical to predict due to the storm drainage systems and outflow sites in the area. Damages from this local flooding appear to be slight.

## ECONOMICS

### FLOOD PREVENTION

Economic investigation and analysis of the Alkali Creek Watershed concentrated on flood prevention. The following section describes the steps and methods of analysis used in determining the economic feasibility of the project.

#### Flood Damage and Benefit Analysis

The newspaper morgue was examined for records of past floods. Information was obtained on floods occurring in 1923, 1937, 1947, and 1958.

Local residents, fair board and county officials, and property owners were interviewed by SCS personnel regarding damages sustained in the fairgrounds and adjacent commercial area.

Damages to fairgrounds and commercial properties in the flood plain were estimated using the evaluation storms and specific data pertaining to each property. These evaluation storms were synthetically developed using hydrologic water surface profile data combined with the results of the TR-20 computer program. Flooding conditions for the 10-, 25-, and 100-year storms were simulated. Water depths for flood plain cross sections were determined for each of the evaluation storms. Elevations were established by engineering surveys. These elevations were used as a basis for estimating ground elevations of buildings. Ground floor elevations were compared to the floodwater elevation to determine flooding depths.

Property values were estimated from insurance values, assessed values, market data information, and the use of assessment to sale ratios. Flooding depths combined with property values and Stanford Research Institute depth damage factors, provided the basis for estimating total flood damages for particular storms.

A damage frequency curve was developed for both with and without project conditions as a means to estimate average annual floodwater damage reduction benefits. Damage estimates for the 100-, 25-, and 10-year frequency storms were developed.

Indirect floodwater damages resulting from such things as traffic detours, disruption of normal community activities, inoculations to prevent disease epidemics, etc., were based on a weighted percentage of direct damage. This percentage was developed from proportions of

various types of damages, i.e., fairgrounds, commercial, and streets and storm sewers, in accordance with Chapter 3 of the Economics Guide and estimated at 20 percent for commercial property, 15 percent for city streets and storm sewers, and 25 percent for fairgrounds property.

Floodrouting analysis indicated that the project would bring about a significant reduction in the area flooded. Remaining damages are confined primarily to streets, storm sewers, and a few low areas in the fairgrounds. These damages are primarily the result of uncontrolled local urban runoff.

#### Land Enhancement

Land enhancement benefits were estimated in the fairgrounds from filling the lower portion of the Alkali Creek channel where excess excavation will be deposited.

#### Cost Savings

Construction cost savings to the Multipurpose Community Center were analyzed as the difference between with and without project conditions. Operations and maintenance in the fairgrounds costs were analyzed. The reduction in O&M costs is a benefit from project installation.

#### Operation, Maintenance, and Replacement Costs

Operation and maintenance costs for structural measures were based on historical data for similar structures. Replacement costs were based on engineering and geologic data.

#### Amortization of Costs

Costs for structural measures were amortized on the basis of 5-5/8 percent over the 100-year life of the project.

#### Impacts on Employment

Project effects on employment were estimated using the procedures outlined in TSC-Technical Note-Watersheds-PO-5.

APPENDIX A



## SUPPLEMENTAL FLOOD HAZARD ANALYSES DATA

### INTRODUCTION

Flood plain delineation along Alkali Creek between the project and Five Fingers Lake site was made a part of this plan at the request of the Yellowstone County Commissioners. Aerial photomaps have been included showing the area affected by the 100-year flood. Additional information in the form of photographs and other related flood plain data are also included.

Flooding results in loss of property, creates health and safety hazards, and disrupts needed services. Flooding also results in high costs to city, county, state, and federal governments, and welfare agencies to repair or replace roads, streets, bridges, rescue and care for the stranded, protect private property, clean up debris, and restore services. These costs are of great concern to all tax-paying citizens. As more and more construction is allowed on flood plains, the governmental costs for future floods will increase. Properly administered flood plain management programs can minimize these costs.

Flood hazards normally increase in developing areas. Urbanization means new homes, schools, businesses, streets, etc. This results in less exposed soil to absorb precipitation and, therefore, more storm runoff. Pavements, roofs, compacted soil, and storm sewers all increase and speed up the runoff, increasing the flood hazard locally and downstream.

There are many competing uses for lands in developing areas. Flood plain lands are no exception. Encroachments into the flood plain by land filling, railroads, highways, channel modification, and other developments can constrict the flow of floodwater. These constrictions can increase floodwater depths and velocities.

Managers and users of flood plain land should base their use decisions upon the advantages and disadvantages of locating within flood hazard areas. Knowledge of the hazards involved is not widespread and, consequently, risks cannot always be accurately assessed.

Flood hazard analyses are carried out by the Soil Conservation Service as an outgrowth of the recommendations in A Report by the Task Force on Federal Flood Control Policy, House Document No. 465, (89th Congress--August 10, 1966), especially Recommendation 9(c), "Regulation of Land Use," which recommended the preparation of preliminary reports for guidance in those areas where assistance is needed before a full flood hazard information report can be prepared or where a full report is not scheduled.

In carrying out flood hazard analyses, the Soil Conservation Service is also being responsive to Executive Order 11296, dated August 10, 1966, especially to Section 1(4), which directs that:

"All executive agencies responsible for programs which entail land use planning shall take flood hazards into account when evaluating plans and shall encourage land use appropriate to the degree of hazard involved."

The order also directs that all federal agencies responsible for administration of federal grants, loans, or mortgage insurance programs involving the construction of buildings, structures, roads, or other facilities evaluate flood hazards to such facilities. The reason was to minimize potential damages and reduce future expenditures for flood protection and disaster relief. The agencies were also directed to require conspicuous delineation of past and probable flood heights to assist in creating public awareness and knowledge of flood hazards.

The 2-, 10-, 25-, and 100-year frequency floods were analyzed. A 25-year frequency flood has an average occurrence of once in 25 years or a four percent chance of occurring in any given year. A 100-year flood occurs once in 100 years on the average or has a one percent chance of occurring in any given year. Only the 100-year flood lines are shown on the aerial photomaps, valley cross sections, and water surface profiles. See Figures 2, 3, and 4. Information for the 10-, 25-, and 100-year floods are shown in flood plain reference tables. Elevations for other frequency storms can be determined from the basic support data on file with the Soil Conservation Service.

The Flood Disaster Protection Act of 1973 (P. L. 93-234, effective December 31, 1973) prohibits, as of March 2, 1974, direct or indirect federal assistance, including that from lending institutions, for the acquisition, construction, repair, or improvement of any building or mobile home within any area previously identified by HUD as having special flood hazards (subject to inundation by a 100-year frequency flood) and for which flood insurance is available, unless the federally assisted owner or occupier carries flood insurance on the building or mobile home and contents in an amount equal to the federal investment or to the maximum limit of insurance coverage available, whichever is less, for the anticipated economic or useful life of the building or mobile home.

Effective July 1, 1975, the Act prohibits federal financial assistance for the acquisition, construction, repair, or improvement of any building or mobile home in any area identified by HUD as having special flood hazards, unless the community in which such area is located is then participating in the national flood insurance program.

In 1971 the Montana Legislature passed legislation to ease the increasing problem of flood loss and damage in Montana. This act was revised by the 1973 and 1974 Legislature. The Montana Floodway Management and Regulation Act, title 89, chapter 35, Revised Code of Montana, authorizes the Montana Department of Natural Resources and Conservation to initiate a comprehensive program of floodway delineation and regulation for the entire state. The purpose of this state-wide flood plain policy is two-fold:

1. To eliminate or minimize loss of life, personal suffering, and physical hardships which are immediate consequences of serious floods.
2. To achieve the optimum beneficial use of our flood plains for both private and public benefits.

Many land uses are compatible with periodic flooding and are permitted within the designated flood plain to the extent that they are not prohibited by any other statute. Some "open space" uses specifically allowed within the designated flood plain are agricultural uses, commercial loading or parking areas, and open-type public and private recreation areas.

Specific recommendations on acceptable flood plain land uses and state standards for flood plain development will be furnished to the Yellowstone Conservation District and the Yellowstone County Commissioners by the Soil Conservation Service and the Montana Department of Natural Resources and Conservation.

In order for flood plain management to be effective, it is necessary to:

1. Provide state and local units of government with appropriate technical information and interpretations for use in flood plain management.
2. Provide technical services to managers of flood plain property to better coordinate planning for development and appropriate land use.
3. Improve basic technical knowledge about flood plain hazards in cooperation with other agencies and groups.
4. Provide conspicuous delineation of past and probable flood heights in order to protect potential future tenants or purchasers of flood plain property from indiscriminate land development.

Descriptions of the watershed, the study area, and the watershed problems have been stated earlier in this work plan. See Figure 5 for the location of the drainage area and study area.

The methods of analysis used for the flood hazard portion of this report are discussed in the Investigation and Analysis, Hydrology, section.

## STUDY RESULTS

This flood hazard study focused on developing information about the 100-year flood plain along Alkali Creek. Much of the information is interrelated and specific data can be obtained from this report in several ways.

The photomaps, Figures 2, 3, and 4, show the area affected by a 100-year flood for "with" and "without" project conditions. Flood plain delineations between the bypass channel and the Five Fingers Lake site are not affected by planned works of improvement. The photomaps also display the location of stream cross sections and water surface profile for the 100-year flood. Floodwater elevations at the surveyed cross sections for the 10-, 25-, and 100-year floods are shown in Table 7 on the following pages. Table 8 lists discharges for the 10-, 25-, and 100-year events at selected cross sections.

To determine the estimated 100-year floodwater elevation at a specific location, refer to the aerial photomaps and locate the nearest upstream and downstream surveyed cross sections. Refer to the water surface profile below for the cross sections and read the flood elevation directly from the graph.

Another method may be used to determine floodwater elevations at a specific location. This method may be used for the 10-, 25-, and 100-year flood elevations. Determine the nearest upstream and downstream cross section from the aerial photomaps. Using Table 7, interpolate between the applicable cross sections to estimate floodwater elevations.

The delineated areas subject to inundation on the photomaps are general in nature. Flood lines between cross sections are based on field evaluations and are drawn from stereoscopic photo coverage of the area. Because the lines are general, they may include small areas that would not be flooded or exclude areas that would be flooded. A careful evaluation should be made for any proposed use in or near the delineated flood plain.

## APPLICATION OF FLOOD HAZARD INFORMATION

This report can be used as a technical tool to help develop local flood plain use guidelines. It is intended to serve as a basis for determining needed action to minimize flood damages. The report will also be used for further study and planning on the part of Yellowstone County, Yellowstone Conservation District, and the Montana Department of Natural Resources and Conservation. Future action could include: local planning programs to guide developments; controlling the permitted uses of flood plains through zoning and subdivision regulations; the construction of flood protection works; or combinations of these approaches. The following preventive measures could be considered in a flood plain management program:

- Land Use Planning
- Flood Plain Control Regulations
- Flood Plain Development Policies
- Flood Plain Filling Regulations
- Flood Plain Acquisition
- Flood Plain Zoning
- Upstream Land Treatment Program
- Flood Warning System
- Flood Insurance
- Tax Adjustments
- Health Regulations
- Building Codes

Corrective or structural measures which would complement the preceding include:

- Floodwater Retarding Reservoirs
- Channel Improvement
- Levees and Dikes
- Pumps
- Floodproofing
- Watershed Treatment
- Urban Relocation

The Montana Department of Natural Resources and Conservation and the Soil Conservation Service will, upon request, provide technical assistance to federal, state, and local agencies and organizations in the interpretation and use of the information developed in this study.

Flood damage prevention can be achieved only through proper recognition of the hazards associated with flood plain development. County commissioners and other responsible local officials will provide leadership in the promotion of wise flood plain use. Comprehensive planning is a necessary prerequisite for proper flood plain management.

Land use planning for the flood-prone areas should include the following provisions:

1. Residential and commercial uses to be located outside the 100-year flood plain. Exceptions could be made for developments in the fringe area if they are properly floodproofed.
2. Minor structures, if permitted in flood-prone areas, would be suitably anchored to prevent flotation.
3. No use should be allowed that increases the elevation of the water surface in the delineated flood plain by more than 0.5 foot.

If the delineated flood plain is narrowed, adequate structural measures should be required. Narrowing of the delineated flood plain will increase flood depths and damages to existing property within the remaining flooded area.

An alternate land use regulation would be the acquisition of flowage easements along each bank of the stream. This procedure would allow the area to pursue a long-range program of channel protection. Nonconforming uses would be eliminated, future encroachments prevented, and channel maintenance assumed as a county and city responsibility.

#### CONTINUED OBSERVATIONS

The data presented in this report have been derived from a history of past flood events. Observation of future flood heights and flood quantities should be continued and the computed values checked and refined by these observations. The assistance of individuals in the flood plain is required for future observations. Local residents should be encouraged to make accurate observations, including photographs of flood heights on their properties. These data should be collected and reported to the local government units.

TABLE 7  
FLOOD PLAIN REFERENCE DATA  
for  
ALKALI CREEK

Surveyed Cross Section Number	Channel Distance Stationing	Streambed Elevation ft. M.S.L.	10-Year Flood Elevation ft. M.S.L.	25-Year Flood Elevation ft. M.S.L.	100-Year Flood Elevation ft. M.S.L.
A-1	0	3082.50	3089.83	3092.40	3092.86
	12+15	3083.90	3090.39	3092.86	3095.00
B	18+80	3086.00	3092.50	3094.01	3095.49
C	22+80	3086.80	3093.14	3094.55	3095.82
D	26+90	3088.40	3094.34	3095.55	3096.86
E	27+40	3088.80	3094.34	3099.07	3100.40
F	36+70	3093.60	3098.43	3101.09	3102.04
G	41+15	3090.60	3100.52	3103.74	3104.45
H	43+70	3099.20	3103.31	3111.07	3111.81
I	44+50	3100.20	3106.34	3111.96	3112.73
J	45+10	3099.50	3108.20	3113.07	3114.94
K	45+70	3100.00	3113.69	3114.74	3116.06
L	46+20	3100.20	3113.69	3115.06	3117.14
M	46+60	3101.00	3113.83	3115.06	3117.14
N	47+70	3100.50	3113.83	3115.06	3117.14
O	49+30	3102.60	3114.67	3115.59	3119.26
P	53+20	3104.20	3114.67	3121.15	3122.74
Q	54+40	3104.60	3119.93	3122.34	3124.24
R	54+85	3105.60	3120.85	3126.81	3128.83
S	63+55	3114.80	3125.45	3128.27	3130.48
T	75+30	3119.00	3126.54	3132.64	3132.80
U	85+70	3120.80	3130.59	3132.64	3132.80
V <sup>1</sup>	86+90	3122.00	3122.00	3132.64	3132.80
V <sup>2</sup>	87+80	3122.00	3122.00	3132.64	3132.80
W	88+40	3122.00	3141.92	3152.42	3158.60
X	91+10	3124.50	3142.11	3152.49	3158.67
Y	93+00	3124.00	3142.30	3152.66	3158.72
Z	107+40	3130.00	3142.90	3153.37	3159.11

TABLE 7 (Continued)  
FLOOD PLAIN REFERENCE DATA  
for Alkali Creek

Surveyed Cross Section Number	Channel Distance Stationing	Streambed Elevation ft. M.S.L.	10-Year Flood Elevation ft. M.S.L.	25-Year Flood Elevation ft. M.S.L.	100-Year Flood Elevation ft. M.S.L.
AA	115+10	3140.00	3148.00	3154.68	3159.32
BB	137+30	3148.40	3158.72	3161.14	3163.05
CC	143+10	3153.00	3160.25	3162.60	3165.20
DD	178+70	3176.20	3180.48	3182.15	3184.68
EE	195+30	3184.20	3192.64	3193.61	3194.81
FF	209+40	3188.50	3196.38	3198.10	3200.28
GG	215+50	3195.20	3203.17	3205.88	3207.79
HH	236+70	3209.50	3215.78	3217.22	3219.04
II	252+87	3223.80	3227.11	3228.29	3229.90
JJ	278+28	3232.50	3239.35	3240.53	3242.20
KK	307+98	3241.50	3250.89	3252.65	3254.92
MM	352+53	3277.50	3280.01	3281.11	3282.77
NN	395+10	3294.50	3297.40	3299.24	3301.53
OO	437+10	3306.50	3312.29	3313.90	3315.99
PP	480+10	3324.50	3327.46	3328.60	3330.33
End of Study	519+10	3353.20	-----	-----	-----

-----10-, 25-, and 100-Year flood elevation not computed-----

TABLE 8  
 FLOOD FREQUENCY DISCHARGE  
 FOR  
 SELECTED CROSS SECTIONS

Cross Section Number	10-Year (cfs)	25-Year (cfs)	100-Year (cfs)
A	1400	2850	4350
E	1500	2950	5450
F	1850	3610	7200
L	1850	3600	7180
U	1850	3600	7180
Z	1880	3680	7290
CC	1870	3670	7260
FF	1860	3650	7230
KK	1810	3550	7080
NN	1670	3290	6540
PP	1620	3190	6400



APPENDIX B



ADDENDUM

January 1975

WATERSHED WORK PLAN  
Alkali Creek Watershed

Yellowstone County  
Montana



## C O N T E N T S

Introduction

Part 1 - Discount Rate Comparison

Part 2 - Display of impacts to national economic development,  
environmental quality, regional development, and  
social well-being accounts

Part 3 - Display of the abbreviated environmental quality  
alternative

## INTRODUCTION

This addendum is based on procedures established for application of the Water Resources Council's Principles and Standards to implementation studies in process.

The Alkali Creek Watershed Work Plan was developed using 1974 installation costs, a 5-5/8 percent discount rate, and current prices, in the evaluation of project structural measures.

Part 1 of this addendum shows the effect of evaluating the structural measures using current installation costs and the current discount rate.

Part 2 of the addendum displays the effects of the selected plan as evaluated for each of the separate accounts--national economic development, environmental quality, regional development, and social well-being. Values for costs, prices, and rates are those of the work plan.

Part 3 of the addendum displays an abbreviated alternative plan developed to emphasize environmental quality. Bases for costs, prices, and rates are those of the work plan.

## DISCOUNT RATE COMPARISON

This shows the effect of evaluating the structural measures using a 5-7/8 percent discount rate, 1974 installation costs, and current prices for values other than agricultural products.

Average annual costs, benefits, and the benefit cost ratio are as follows:

1. Average annual costs are \$40,600.
2. Average annual benefits are \$76,660.
3. The benefit:cost ratio is 1.9:1.0.

SELECTED ALTERNATIVE  
 NATIONAL ECONOMIC DEVELOPMENT ACCOUNT  
 Alkali Creek Watershed, Montana

<u>Components</u>	<u>Measures of Effects 1/</u> - - - Dollars - - -	<u>Components</u>	<u>Measures of Effects 1/</u> - - - Dollars - - -
<b>Beneficial effects:</b>			
A. The value to users of increased outputs of goods and services		A.	The value of resources required for a plan
1. Flood prevention	46,620	1. Bypass channel and diversion dam	
2. Cost savings	15,190	Project Installation	33,560
3. Land enhancement	<u>10,110</u>	Project Administration	3,160
		OM&R	<u>2,310</u>
Total beneficial effects	71,920	Total adverse effects	39,030
		Net beneficial effects	32,890

March 1974

1/ Average Annual

SELECTED ALTERNATIVE  
ENVIRONMENTAL QUALITY ACCOUNT  
Alkali Creek Watershed, Montana

Components

Measures of Effects

Beneficial and adverse effects:

- |   |   |   |   |
|---|---|---|---|
| A. Areas of natural beauty                                  | 1. Project development will eliminate trash and debris near the fairgrounds.  | C. Biological resources and selected ecosystems | 1. Project will eliminate flows in 4,500 ft. of modified channel on Alkali Creek. (6.7 acres of channel area) |
|   | 2. Reduced floodwater damages at the fairgrounds will allow funds to be spent for other uses such as landscape development. |   | 2. Of the 6.7 acres of channel area, 4.0 acres will be filled, 2.7 acres will remain unaltered.               |
|   | 3. Flood plain management will help preserve 200 acres of streambank habitat along Alkali Creek.                            |   | 3. Habitat for fish and aquatic life will be provided in the outlet channel. (365 feet long by 75 feet wide)  |
|   | 4. The bypass channel and diversion dam will affect visual quality in lower Alkali Creek.                                   |   | 4. Land treatment measures will enhance cover and habitat in the watershed.                                   |
| B. Quality considerations of water, land, and air resources | 1. Land treatment will reduce erosion and sedimentation in the watershed.   | D. Historical, archeological, and geological    | 1. Project will not affect any historical or archeological site in the watershed.                             |
|   | 2. Air and water pollution will be increased during construction.   |   |   |
|   | 3. Reduced flooding of 165 acres of urban, business, and fairgrounds will improve human environment.                        |   |   |

SELECTED ALTERNATIVE  
ENVIRONMENTAL QUALITY ACCOUNT (Continued)  
Alkali Creek Watershed, Montana

Components

Measures of Effects

Beneficial and adverse effects:

- E. Irreversible or Irretrievable commitment
1. The bypass channel and diversion dam will require 7 acres of land. (2.1 acres of bottomland along the Yellowstone River, 0.7 acre sandstone terrace, 0.3 acre rimrock bluff, 1.8 acres of railroad spur and roadway, and 2.1 acres of Alkali Creek flood plain)
  2. The bypass channel and diversion dam may require 5.1 acres of Alkali Creek flood plain for borrow material.

SELECTED ALTERNATIVE  
REGIONAL DEVELOPMENT ACCOUNT  
Alkali Creek Watershed, Montana

	Measures of Effects <sup>1/</sup>			
	State of Montana	Rest of Nation	Income:	Rest of Nation
	- - - Dollars - - -			- - - Dollars - - -

Components	Components
------------	------------

Income:

Measures of Effects <sup>1/</sup>
State of Montana

Beneficial effects:  
Adverse effects:

- A. The value of increased output of goods and services to users residing in the region.

1. Flood prevention
2. Cost savings
3. Land enhancement

46,620  
15,190  
10,110  
---  
---

- B. The value of output to users residing in the region from external economies.

1. Induced by and stemming from effects

3,750

Total beneficial effects

75,670

	Measures of Effects <sup>1/</sup>			
	State of Montana	Rest of Nation	Income:	Rest of Nation
	- - - Dollars - - -			- - - Dollars - - -

	State of Montana	Rest of Nation	Income:	Rest of Nation
Project Installation	18,130			15,430
Project Administration	270			2,890
OM&R	2,310			0
Total adverse effects	20,710			18,320
Net beneficial effects	54,960			-18,320

1/ Average annual

Part 2-4

March 1974

SELECTED ALTERNATIVE  
 REGIONAL DEVELOPMENT ACCOUNT (Continued)  
 Alkali Creek Watershed, Montana

Components	Measures of Effects		Components		Measures of Effects	
	State of Montana	Rest of Nation	Employment:	State of Montana	Rest of Nation	
<b>Beneficial effects:</b>						
A. Increase in number and types of jobs						
1.	Employment for project construction	5.5 skilled jobs for one year	---	Total adverse effects	0.2 permanent semi-skilled job	0
2.	Employment for project OM&R	0.1 permanent semi-skilled job		Net beneficial effects	14 skilled jobs for one year	
3.	Employment in service and trade activities induced by and stemming from project operation	8.5 skilled jobs for one year			-0.1 permanent semi-skilled job	
Total beneficial effects				14 skilled jobs for one year		
					0.1 permanent semi-skilled job	
<b>Adverse effects:</b>						
A. Decrease in number and types of jobs						
					0.2 permanent semi-skilled job	0

SELECTED ALTERNATIVE  
REGIONAL DEVELOPMENT ACCOUNT (Continued)  
Alkali Creek Watershed, Montana

Components	Measure of Effects	Rest of Nation
State of Montana		
Regional economic base and stability	The project will provide more than a one percent level of protection to a portion of Billings, including the Yellowstone County Fairgrounds. A total of \$9,709,000 of property will be protected. The project will create 14 skilled jobs for one year.	---
Beneficial effects:	Flood prevention is an integral part of the development and enhancement of the Yellowstone County Fairgrounds.	
Adverse effects:	The fairgrounds serves a multi-county area in southern Montana and northern Wyoming throughout the year. Exhibits and displays produce educational and entertainment values. Agricultural interests are enhanced through livestock exhibitions, auctions, displays, and other fair activities.	---

SELECTED ALTERNATIVE  
 SOCIAL WELL-BEING ACCOUNT  
 Alkali Creek Watershed, Montana

Component

Measures of Effects

Beneficial and adverse effects:

- A. Real income distribution
  - 1. Create 14 man-years of skilled employment.
  - 2. Cause a loss of 0.1 man-year of semi-skilled employment.
  - 3. Create regional income distribution of \$46,620 flood damage reduction benefits by income class as follows:

<u>Income Class</u> ---Dollars---	<u>Percentage of Adjusted Gross Income in Class</u>	<u>Percentage of Benefits in Class</u>
Less than 3,000	9	8
3,000-10,000	49	45
More than 10,000	42	47

- 4. Local cost to be borne by region totals \$20,710 with distribution by income class as follows:

<u>Income Class</u> ---Dollars---	<u>Percentage of Adjusted Gross Income in Class</u>	<u>Percentage of Contributors in Class</u>
Less than 3,000	9	8
3,000-10,000	49	45
More than 10,000	42	47

March 1974

SELECTED ALTERNATIVE  
SOCIAL WELL-BEING ACCOUNT (Continued)  
Alkali Creek Watershed, Montana

Component

Beneficial and adverse effects:

- B. Life, health, and safety
  - 1. Provide more than a one percent level of flood protection in a 165-acre urban and commercial area. Future threats of loss of life and the need for immunizations will be reduced.
- C. Educational, cultural, and recreational
  - 1. Protection from flooding of the Yellowstone County Fairgrounds.
  - 2. Maintain and enhance the social and cultural aspects of the fairgrounds for all people to enjoy.

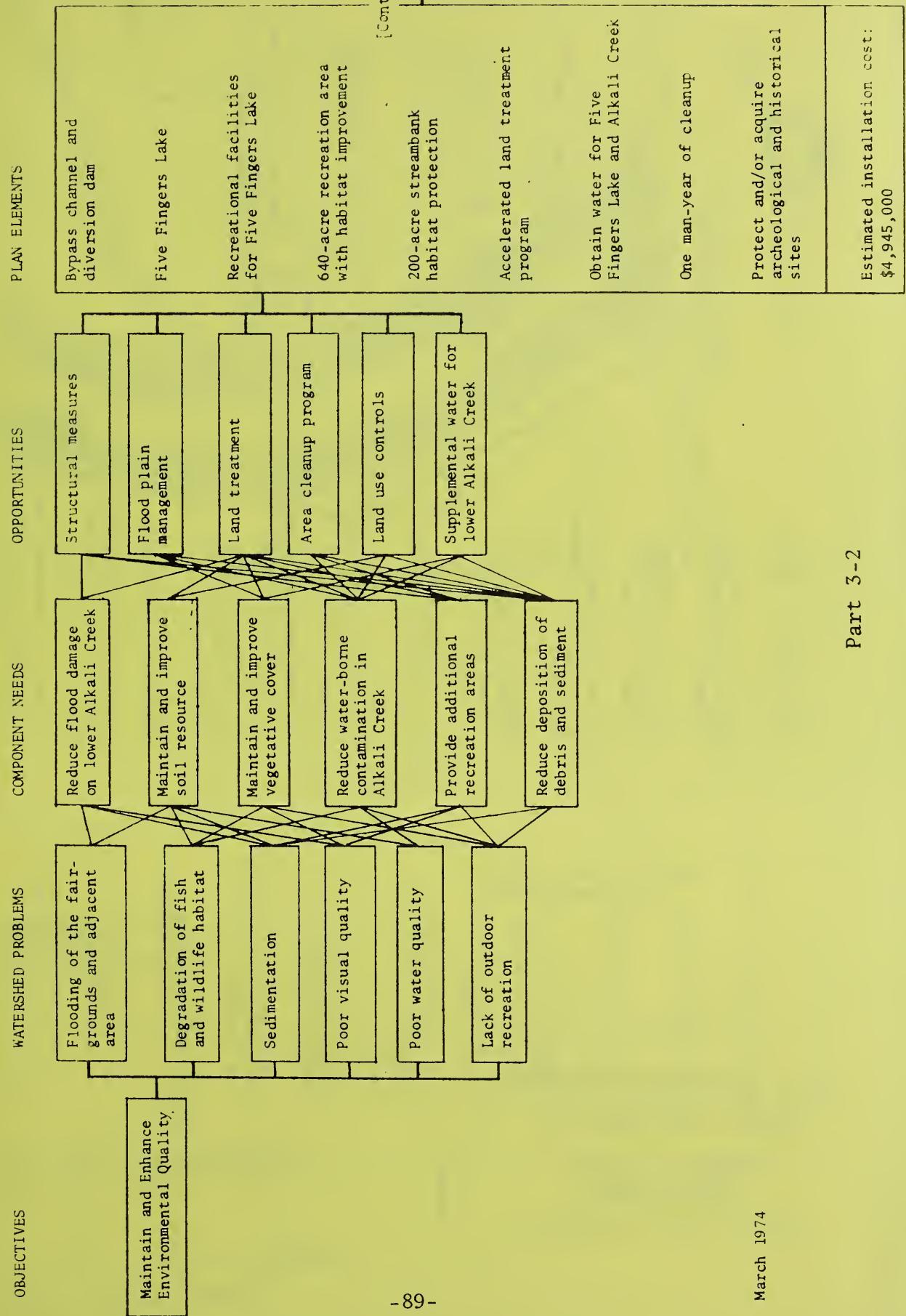
Measures of Effects

## ABBREVIATED ENVIRONMENTAL QUALITY ALTERNATIVE

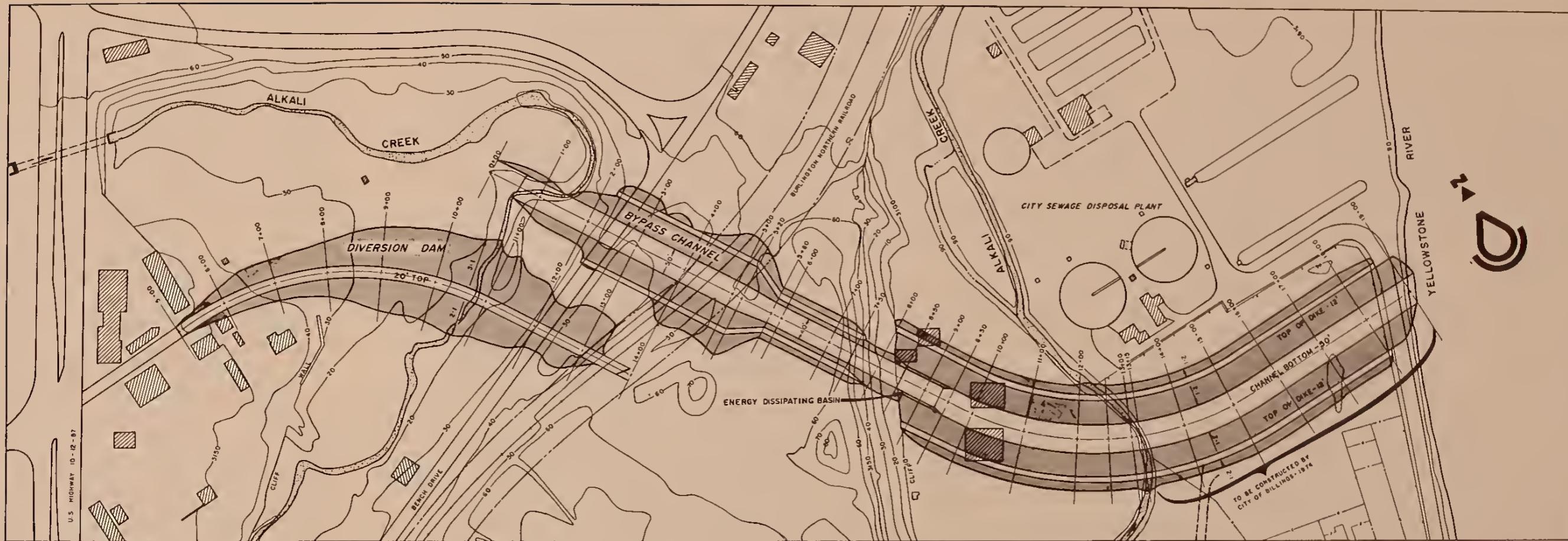
The abbreviated environmental quality plan has been developed by an interdisciplinary team using information and data assembled during investigations and analysis for the watershed work plan. The procedure used in developing the alternative and its content are included on a flow chart. This procedure begins with recognition of the watershed problems and needs. Desired environmental effects or component needs are translated from the problems and needs and provide a base for examining appropriate water and land resource use and management opportunities. Opportunities that emphasize contributions to the component needs were selected and are shown as plan elements of the alternative. The interrelationship of each step in this procedure is illustrated on the flow chart. The cost of \$4,945,000 for its installation is a preliminary estimate. The expected environmental effects of the alternative are shown.

Implementation of features of this alternative would require acceptance by the local people. Adequate legislative authorities exist for implementation; however, funding is presently not available.

ENVIRONMENTAL QUALITY ALTERNATIVE  
Alkali Creek Watershed  
Montana



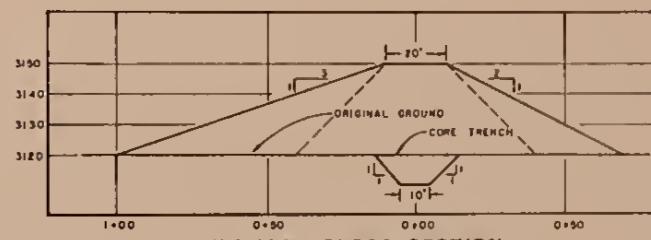
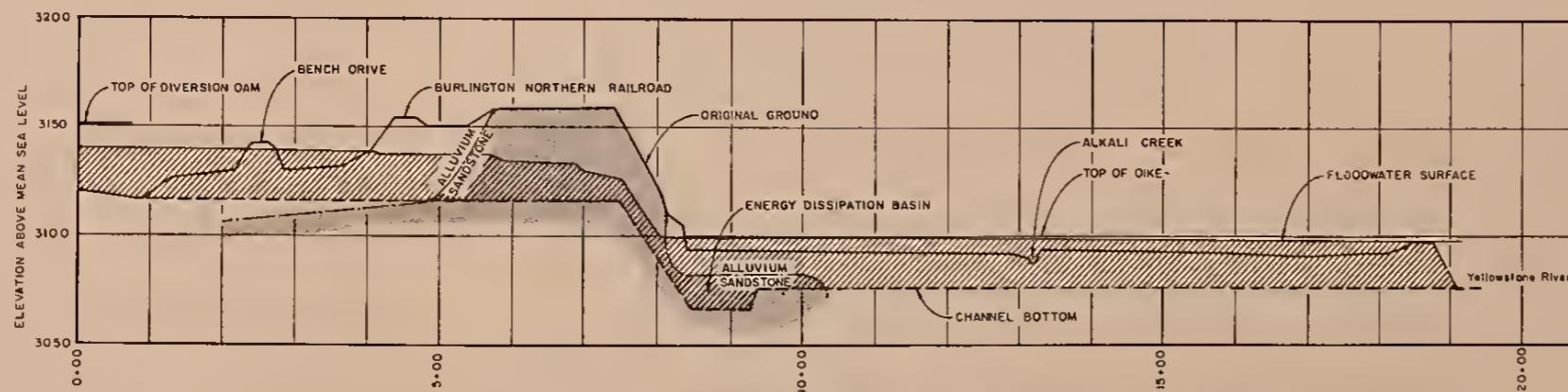
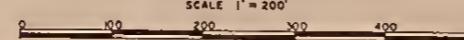
- |  |  |  |
|--|--|--|
| <b>AREAS OF NATURAL BEAUTY</b> <ol style="list-style-type: none"> <li>1. Eliminate trash and debris near fairgrounds.</li> <li>2. Opportunities increased for landscape development.</li> <li>3. 200 acres of streambank habitat will be preserved and protected.</li> <li>4. Structural measures will affect visual quality of the valley landscape.</li> <li>5. 220 acres of flat water will be created.</li> <li>6. Additional vegetation will result from lake and recreation area development.</li> <li>7. Supplemental streamflow will enhance the Alkali Creek channel appearance.</li> <li>8. Cleanup Program will improve the appearance of the watershed landscape.</li> </ol> | <b>GEOLOGICAL, ARCHEOLOGICAL, AND HISTORICAL RESOURCES</b> <ol style="list-style-type: none"> <li>4. Fragile landscape areas may be damaged by recreational use.</li> <li>5. Reservoir will reduce erosion and downstream sedimentation.</li> <li>6. Protection of streambank vegetation will reduce streambank erosion.</li> <li>7. Supplemental flows in Alkali Creek will improve water quality.</li> <li>8. Cleanup program will improve water quality in lower Alkali Creek.</li> </ol> | <b>BIOLOGICAL RESOURCES AND SELECTED ECOLOGICAL SYSTEMS</b> <ol style="list-style-type: none"> <li>9. 4 acres of abandoned channel will be filled; 2.7 acres will be unaltered.</li> </ol> |
|--|--|--|
- IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS**
1. Indian pictographs will be protected and accessible for public appreciation.
  1. Bypass channel and diversion dam will result in the loss of 2.1 acres of bottomland; 0.7 acre of sandstone terrace; 0.3 acre of rimrock bluff; 1.8 acres of railroad spur and roadway; and 2.1 acres of Alkali Creek flood plain.
  1. Multipurpose reservoir will result in a loss of 35 acres of streambank habitat and 185 acres of bottomland pasture.
  1. Habitat will be provided for fish and aquatic life in outlet channel.
  2. Land treatment will enhance cover and habitat.
  3. Fish and wildlife habitat will be provided in the 220-acre lake.
  4. Utility relocation will damage cover and habitat.
  5. Additional wildlife habitat created in the recreation area.
  6. 200 acres of streambank habitat will be preserved and protected.
  7. Supplemental streamflow will provide habitat for wildlife.
  8. Bypass channel will eliminate 4,500 feet of modified Alkali Creek channel (6.7 acres of channel area).



BASE MAP PREPARED BY CHRISTIAN, SPRING, SIELBACH, & ASSOCIATES,  
BILLINGS, MONTANA, FROM AUGUST 13, 1971 PHOTOGRAPHY.

### PLAN VIEW

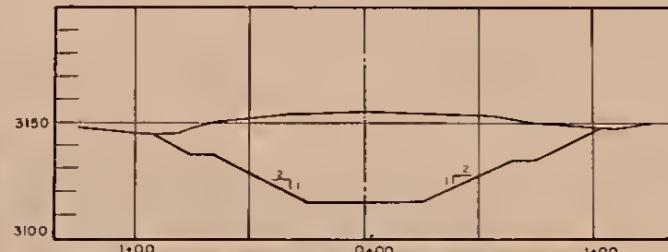
SCALE 1' = 200'



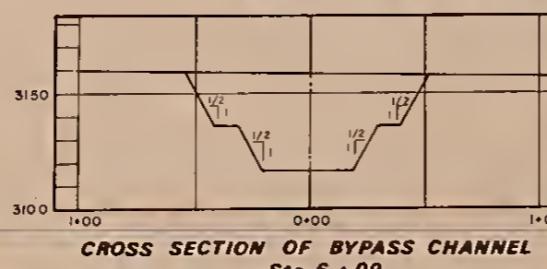
TYPICAL CROSS SECTION  
DIVERSION DAM

FIGURE 1

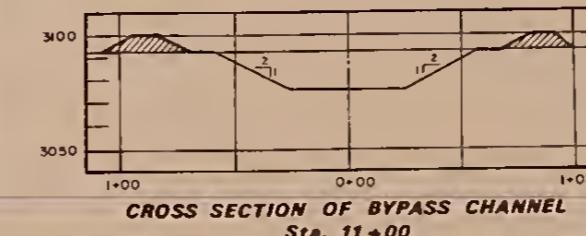
### PROFILE OF BYPASS CHANNEL



CROSS SECTION OF BYPASS CHANNEL  
Sta. 4+50



CROSS SECTION OF BYPASS CHANNEL  
Sta. 6+00



CROSS SECTION OF BYPASS CHANNEL  
Sta. 11+00

### BYPASS CHANNEL AND DIVERSION DAM

#### ALKALI CREEK WATERSHED

YELLOWSTONE COUNTY, MONTANA

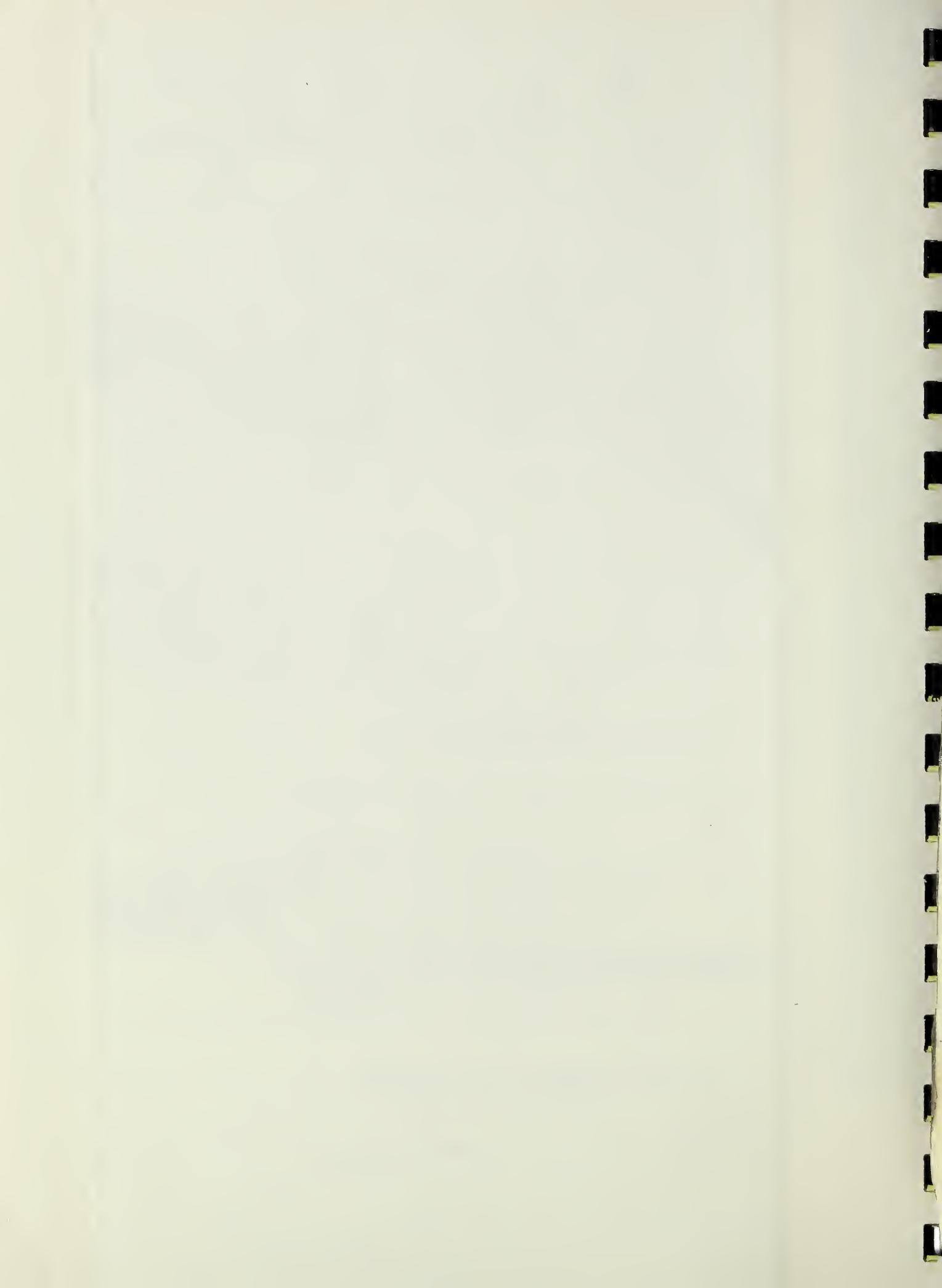




Figure 2

## Flood Hazard Photomap and Water Surface Profiles

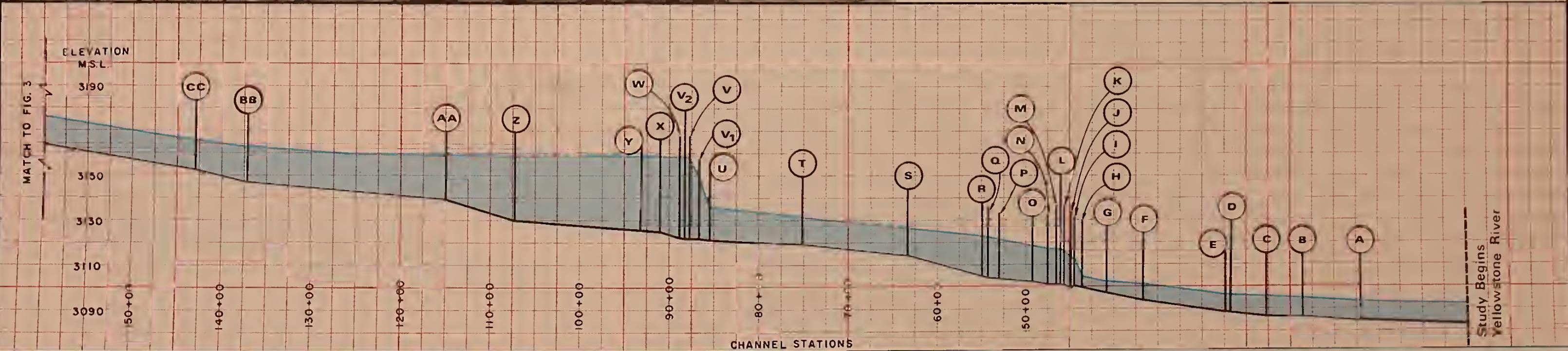
### ALKALI CREEK WATERSHED

Yellowstone County, Montana

- 100-Year Flood With Project
- 100-Year Flood Without Project
- 100-Year Flood From Yellowstone River (U. S. Army Corps of Engineers)
- Valley Cross Section

Data for 100-year flood line between section "J" on Figure 2 and section "GG" on Figure 3, based on U. S. Army Corps of Engineers Report, 1969.

1:12,000  
0 5 10 20  
SCALE IN HUNDREDS OF FEET





0 5 10 20  
SCALE IN HUNDREDS OF FEET  
1:12,000

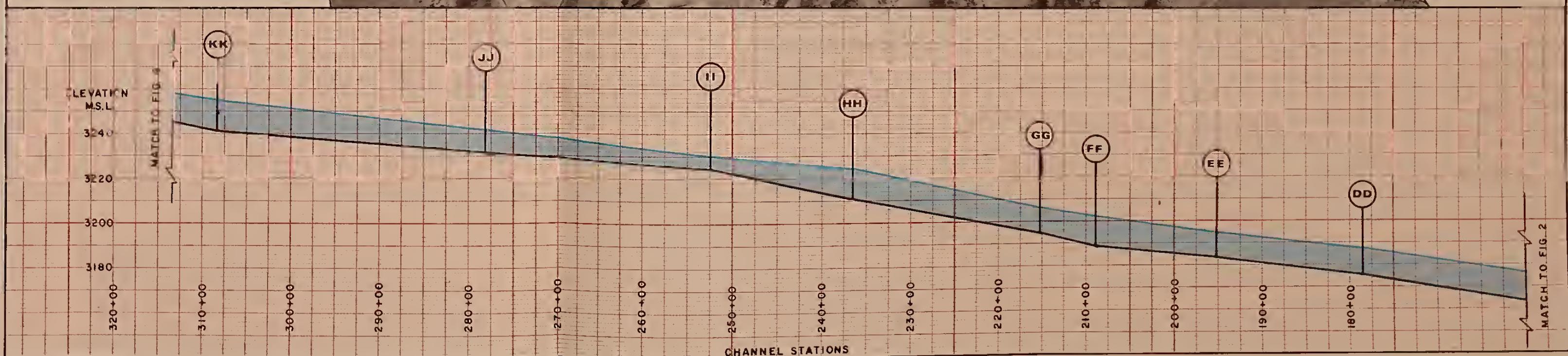
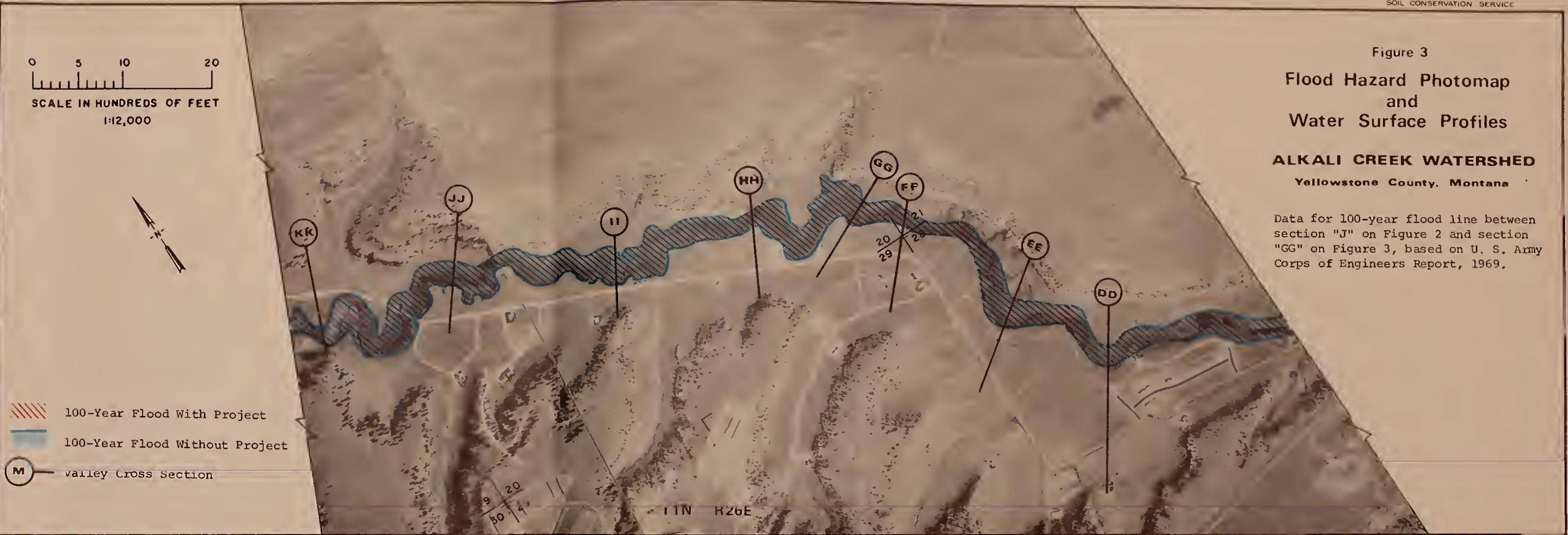
Figure 3

Flood Hazard Photomap  
and  
Water Surface Profiles

**ALKALI CREEK WATERSHED**

Yellowstone County, Montana

Data for 100-year flood line between section "J" on Figure 2 and section "GG" on Figure 3, based on U. S. Army Corps of Engineers Report, 1969.



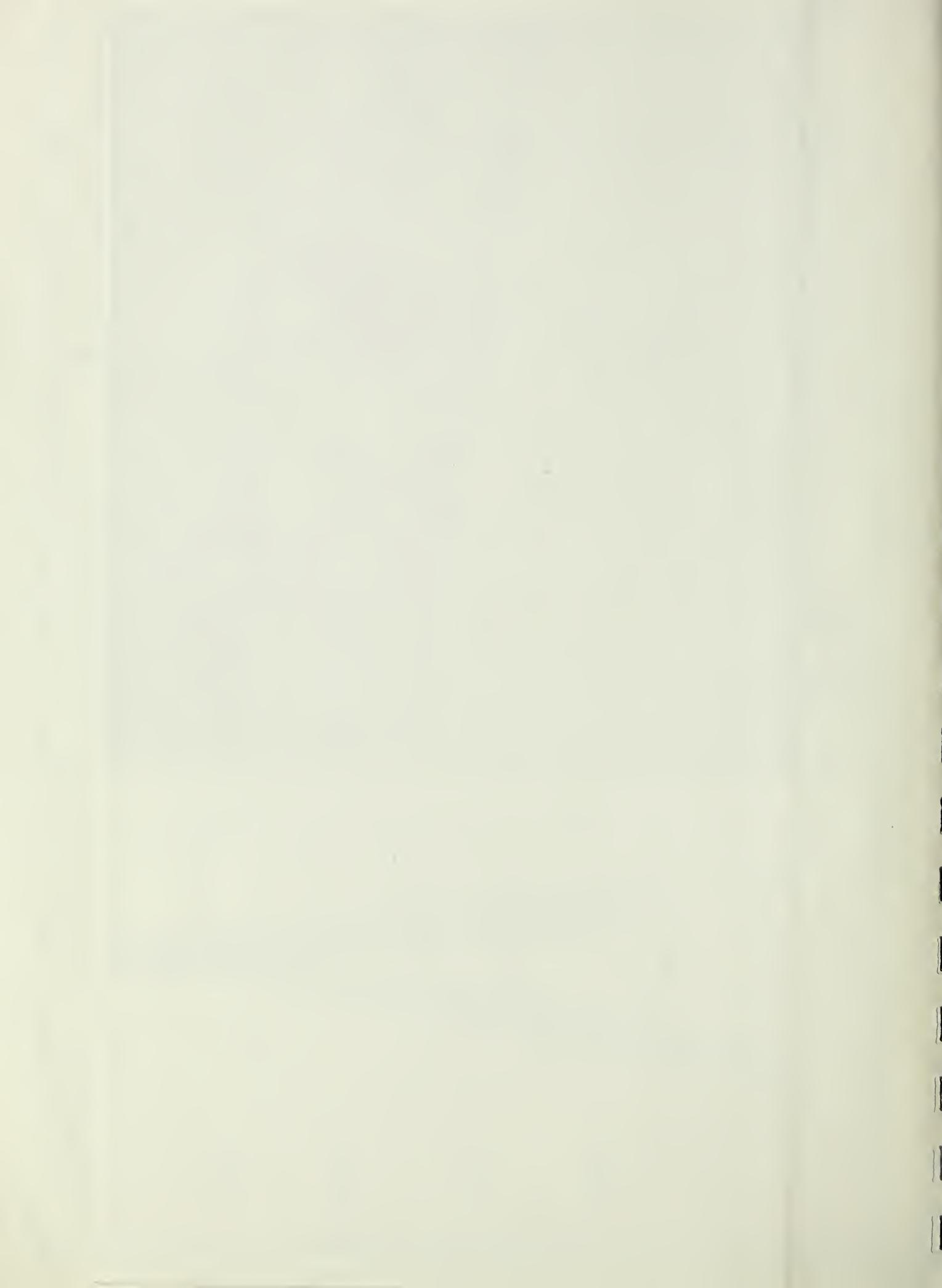


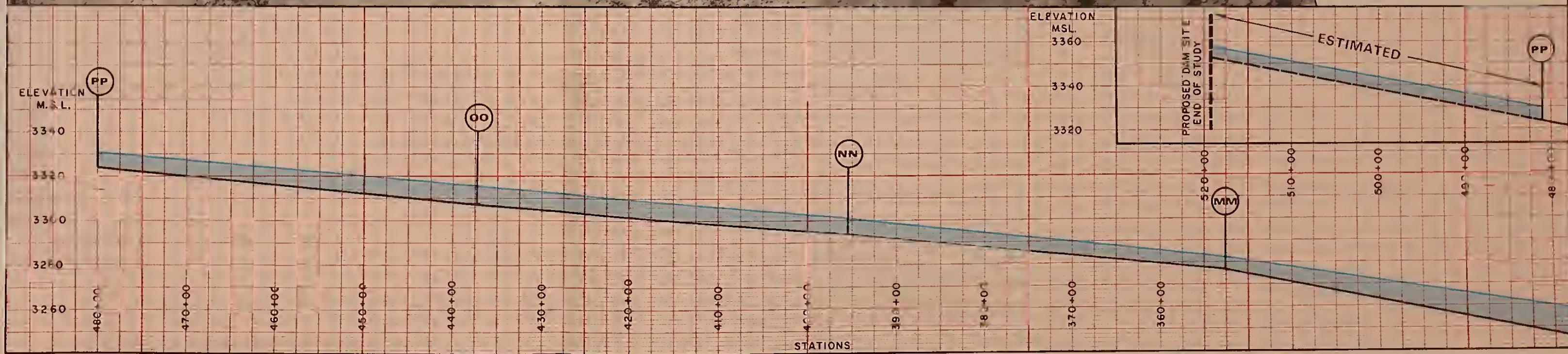
Figure 4

Flood Hazard Photomap  
and  
Water Surface Profiles

**ALKALI CREEK WATERSHED**

Yellowstone County, Montana

- 100-Year Flood With Project
- 100-Year Flood Without Project
- Valley Cross Section





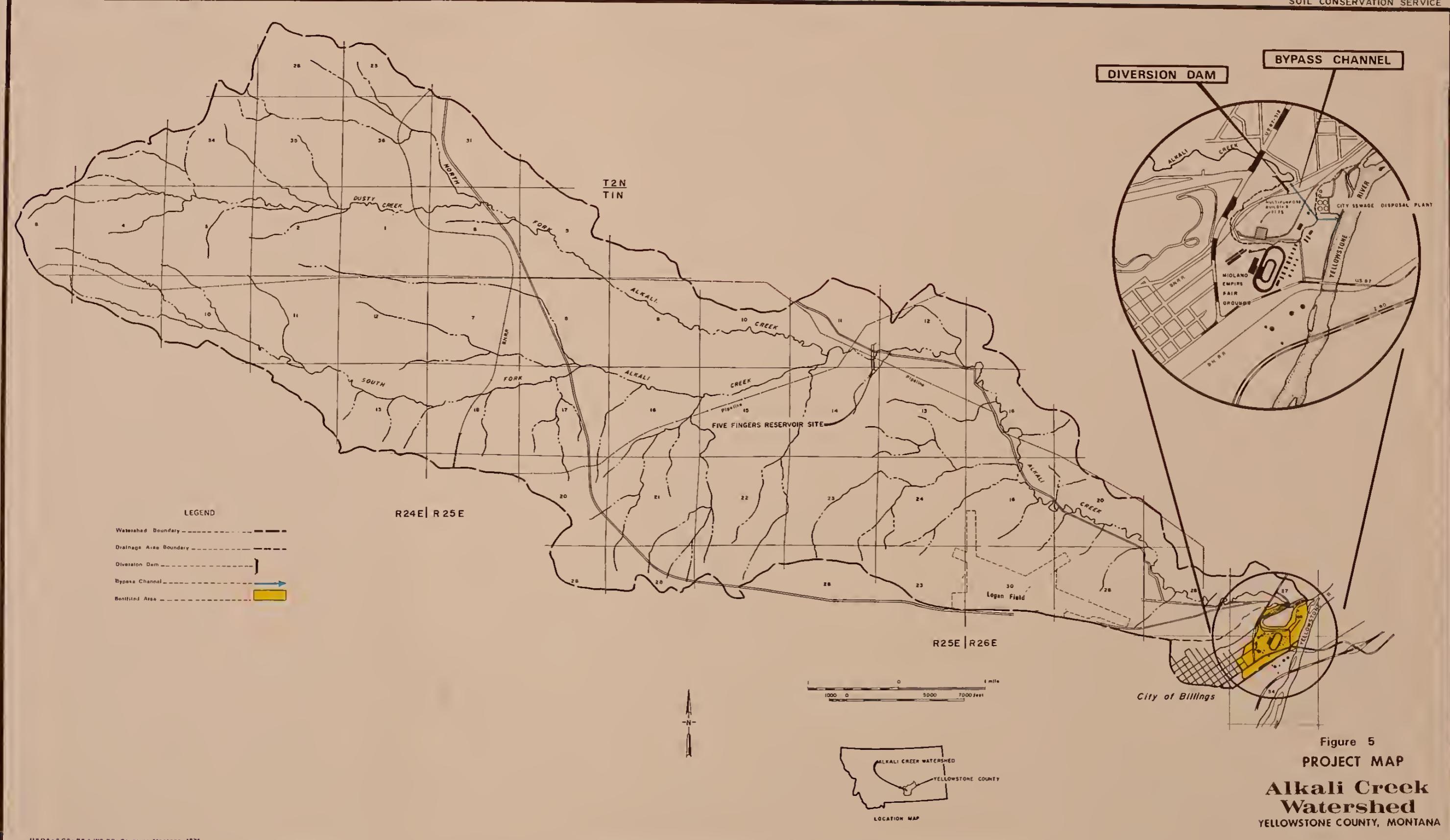


Figure 5  
PROJECT MAP

**Alkali Creek  
Watershed**  
YELLOWSTONE COUNTY, MONTANA

